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Related to the Silicate Industries

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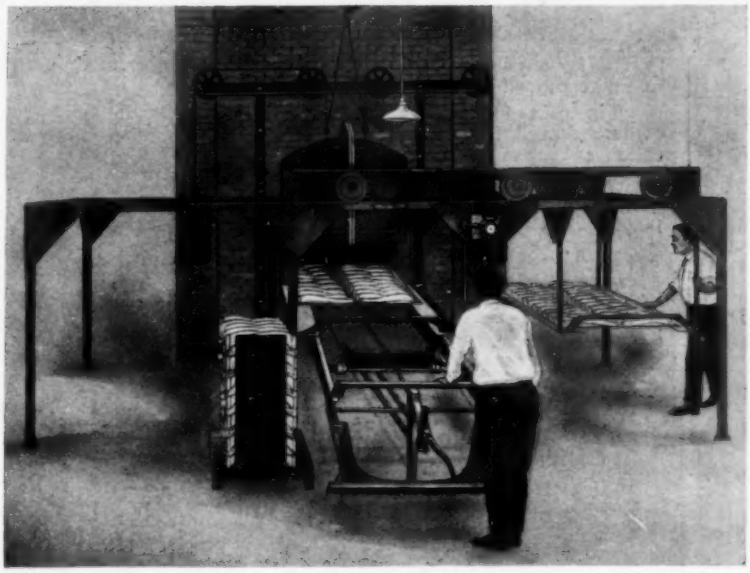

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ORIGINAL PAPERS

A STUDY OF PLASTICITY BY PRACTICAL POTTER'S METHODS[1]

By Paul E. Cox

ABSTRACT

By the use of the potter's wheel it is shown that bentonite added to non-plastic and lean ceramic materials will produce plasticity of the same quality as that found in high grade ball clays. Curves show the results obtained. The colloid theory of plasticity is sustained and it is demonstrated that mineral colloids of the type of the bentonites are of great value in ceramic work where plasticity is highly important.

Introduction

The colloid theory of plasticity has been generally accepted as correct. The object of the work described has been to develop plasticity in non-plastic and short mineral mixtures by the addition of the colloidal mineral bentonite.

Method of Experimental Work

All proportioning of mineral materials was done by dry weight. The first series of experiments was run on mixtures of calcined Florida clay and bentonite, while the second series of experiments was run on North Carolina kaolin and bentonite.

The mixtures of calcined Florida clay and bentonite were wet ground in a ball mill until they would pass a 100-mesh sieve, then dried on plaster until stiff enough to work on the potter's wheel. The mixtures of North Carolina kaolin and bentonite were covered with water, slaked, and lawned

[1] Presented at the Atlantic City Meeting, February, 1924.

through a 60-mesh sieve and dried on plaster until stiff enough to work on the potter's wheel. Vases were made from all the mixtures that were plastic enough to permit of this process. As a standard of plasticity under this method, Kentucky ball clay was used. The Kentucky ball clay was drawn into as thin-walled a vase as was possible and the other samples were made to match this vase as nearly as possible. All pieces so made were burned at cone 02 in a small commercial kiln.

Wheel Technique Used

The methods followed by the stoneware turner were used in forming the vases. A stoneware potter working on the wheel is known as a turner and does not manipulate his clay as does the whiteware thrower. The ball is centered without forcing the clay to rise into a slender cone which is then forced down again, as is the custom of the whiteware thrower. The ball is then opened either with the fingers or the ball opener. Short clays will split in vertical cracks under this process.[1] All mixtures were rejected as non-plastic which split in opening or which would not yield wares which would be commercially possible of production, under the conditions of the experiments.

Results

Results are shown plotted with the percentages of bentonite on the abscissas and the ease of forming or plasticity on the ordinates. The calcined Florida clay was sensibly coarser than the North Carolina kaolin, which explains the difference in the curves. The plasticity percentage had, of course, to be estimated.

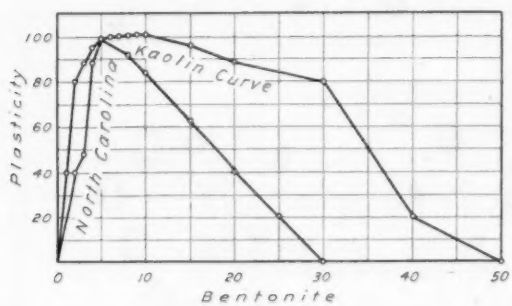

FIG. 1.

Conclusions

1. Bentonite has no plasticity under the conditions of the experiment.

2. Wet ground calcined clay has no plasticity under the conditions of the experiment.

3. Bentonite added to some mineral mixtures will produce plasticity. This plasticity is the exact plasticity found in clays liked by the practical potter.

[1] Many experiments have proved that clays which behave well on the potter's wheel will behave accordingly on brick and tile machines.

4. North Carolina kaolin mixed with bentonite can be made to have all the plasticity of a high grade ball clay.

5. If a bentonite or similar mineral can be found that is sufficiently free from iron to yield a white burning product, whiteware can be as easily formed as wares made from Number 2 fire clays and the shales of the very plastic sort. There would need to be no more short bodies.

6. It is evident that the finer the grain of the treated mineral the more of the colloidal mineral will be required to effect plasticity. Surface factors are therefore important.

7. It was found that the fusion points of the minerals tested were lowered by the addition of the bentonite. Since very little bentonite causes great increases in plasticity in the coarser grained minerals, this lowering of fusion point can be controlled, when desired.

8. The colloid theory of plasticity has great value in the synthesis of plastic ceramic mixtures.

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A SIMPLE BRICK POROSIMETER[1]

By E. E. Pressler[2]

ABSTRACT

A brick porosimeter based upon the air-expansion principle is described, and various considerations of design discussed. The apparatus described is adapted for testing refractory brick, but the considerations of design presented are general in character. The design is adapted for commercial control work, and the descriptions serve as complete construction references.

Porosity values obtained by the porosimeter and water absorption methods are compared to the values calculated from true sp. gr., to indicate the relative accuracy of the methods.

Introduction

The air-expansion principle for determining open pore space of brick was suggested by Washburn and Bunting.[3] A practical application of the principle in a brick porosimeter was made by Bole and Jackson.[4] The design herein described is developed from this apparatus.

The primary object has been to perfect a porosimeter suitable for rapid routine control testing. A simple and rigid construction, in which refinements for accuracy are under control, is therefore employed.

The Apparatus

The assembled apparatus is shown in Fig. 1. The brick container is made of $^1/_4$-inch rolled boiler plate steel, with inside dimensions slightly larger than the standard dimensions of refractory brick. A cover plate, of the same material, is fixed with 8 wing nut bolts and made air tight by a rubber gasket $^1/_{32}$-inch thick. A simple open-end manometer is connected directly with the brick container. A Cenco-Nelson vacuum pump driven by $^1/_8$-h. p. motor, exhausts the air from the container. A one-liter acid bottle is used as an auxiliary air container. To the air inlet tube is connected an air-drying attachment, which will be discussed later more fully.

Procedure of Testing

A dry brick is placed in the container, the gasket seal is rendered air-

[1] The writer wishes to express his appreciation for many helpful suggestions and criticisms received from G. A. Bole and F. G. Jackson of the Ceramic Station of the U. S. Bureau of Mines, Columbus, Ohio and R. C. Purdy, General Secretary of the American Ceramic Society.

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[2] Ceramic Assistant, U. S. Bureau of Mines, Ohio State University, Columbus, Ohio.

[3] "Porosity VII. The Detn. of Porosity of Highly Vitrified Bodies," *Jour. Amer. Ceram. Soc.*, **5** [8], 535–37 (1922).

[4] "A Simple Control Porosimeter," *Brick & Clay Rec.*, **61** [5], 314–15 (1922).

tight by a light application of vacuum wax, and the cover plate bolted down securely. The desired degree of vacuum is created in the brick container, while the auxiliary air container is adjusted to atmospheric pressure. The manometer is read when connected with the brick container alone, and again when the two containers are connected. Several check readings are usually taken. The brick is then removed and its volume determined by calipers, if of regular shape, and if not, by water displacement.

The Containers

Washburn and Bunting[1] pointed out that the first partial vacuum may be induced in either the test piece container or the auxiliary air container. If the pump is connected directly to the test piece container, a smaller auxiliary air volume will suffice to give the desired manometer scale range. The direct connection is preferred for the further reason that the suction of the pump may then be used to remove from the system any adsorbed gas or liquid in the brick, which volatilizes at the reduced pressure.

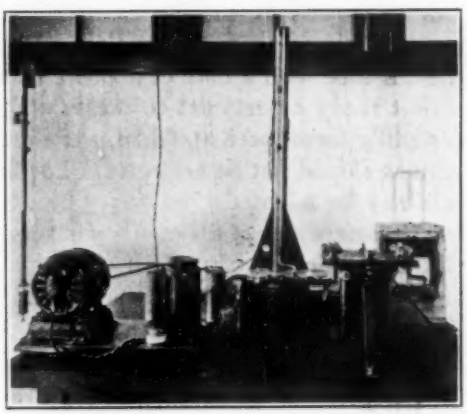

FIG. 1.

The gasket and bolted cover plate method of closure is found to be more effective than a glass plate ground in place. Practical tests indicate that the application of pressure is necessary to prevent leakage under high pressure-differences.

To secure the desired rigidity, the brick container is set into a fixed position on the supporting base, and firmly fastened by means of an iron collar and legs.

Relative Size of Containers

It is desired to keep total volumes small so that manometer readings may be as sensitive as possible. To allow for irregularities in the shape and size of bricks to be tested, the brick container is designed with a tolerance of $^1/_4$-inch in each dimension above the standard size of refractory brick. When an average brick is enclosed, the free air space plus the open pore space are from 700 to 900 cubic centimeters. If an auxiliary air container

[1] "Porosity VI. Determination of Porosity by the Method of Gas Expansion," *Jour. Amer. Ceram. Soc.*, **5** [2], 115 (1922).

of approximately equal capacity is used, the maximum range of manometer scale may be utilized without introducing relations of pressure and volume which tend to make calculations inexact.

The Manometer

Certain advantages in the use of an inclined scale manometer are pointed out by Bole and Jackson,[1] but this refinement complicates construction and calculations and therefore is not used in this design. A vertical open end manometer is preferred to a closed end manometer or simple barometer, for convenience in taking readings. It requires the observation of only one mercury column level, since the other is kept stationary, whereas the sealed end type requires observation of both mercury column levels.

A manometer tube of the least cross-section which will allow free movement of mercury is desirable, from considerations of accuracy and design. A glass tube with a bore of about 2.7 millimeters is used, but it does not permit ready adjustment to pressure changes without vigorous tapping. A slightly larger bore would be preferable for this reason, but even then, tapping should not be neglected. For tapping the tube, an electric doorbell may be adapted.

The surface area of the mercury in the pan is such that the varying height of the mercury column will not cause a significant variation in the level of mercury in the pan. The minimum allowable mercury surface is calculated from the ratios:

$$\frac{\text{area of manometer section}}{\text{area of mercury surface in pan}} = \frac{\text{max. variation in pan level}}{\text{av. depr. of mercury column}}$$

With a manometer tube bore of 0.055 square centimeter, an average mercury column depression of 40 centimeters, and a maximum variation in pan mercury level of 0.01 centimeter, the minimum area of pan mercury surface, $X = \frac{.055 \times 40}{0.01} = 220$ square centimeters. A 6 x 8-inch hard rubber photographer's washing tray is convenient for this purpose.

The mercury pan is set in a wooden frame about 6 inches above the general table level. The manometer tube is attached to a meter stick, and fixed by screws and cork washers to an upright standard extending from the mercury pan support. The manometer tube should extend at least 76 centimeters above the lower mercury surface.

Calibration

The volume of each container together with its immediate connections, is determined directly by weighing when empty and filled with distilled water. The true volumes are obtained by dividing the observed volumes

[1] Bole and Jackson, *loc. cit.*

by the relative density of water at the temperature of weighing. The volumes of the various connections and the manometer tube bore are found by determining the weight of mercury required to fill them, and dividing by the specific gravity of mercury.

The volume of the connections included with the brick container, and the section of manometer tube bore up to the mercury column height for the first reading, are included as a part of the brick container. The volume of manometer tube bore added to the system incident to connecting the auxiliary air container is computed, and this is considered as an integral part of the volume of the air container. Using the values thus obtained, the volumes of the empty containers are checked against each other by test trials.

Method of Calculation

Let V_1 = corrected volume of brick container
V_2 = corrected volume of auxiliary air container
R_1 = first reading of mercury column
R_2 = second reading of mercury column
P_1 = pressure indicated by R_1
P_2 = pressure indicated by R_2
P_B = barometric pressure
V_B = bulk volume of brick
P = per cent porosity
V_1^1 = total air space in brick container with a brick inserted, including the open pore space of the test brick.

Assuming constant temperature and barometric pressure, the relations with a brick in place are:

$$V_1^1 P_1 + V_2 P_B = (V_1^1 + V_2) P_2 \qquad (1)$$

Since actual pressures are measured by differences in mercury column levels,

$$P_1 = P_B - R_1$$
$$P_2 = P_B - R_2$$

Substituting in (1):

$$V_1^1(P_B - R_1) + V_2 P_B = V_1^1 P_B - V_1^1 R_2 + V_2 P_B - V_2 R_2 \qquad (2)$$

Canceling and collecting,[1]

$$V_1^1 = \frac{V_2 R_2}{R_1 - R_2}$$

Hence:

$V_1 - V_1^1$ = skeleton volume of brick
$V_B - (V_1 - V_1^1)$ = open pore space of brick

[1] It will be observed that barometric pressure is eliminated from the equation by cancellation, hence the use of actual barometric readings is not required.

$$P = \frac{V_B - (V_1 - V_1^1)}{V_B} \times 100^1 \qquad (3)$$

Sources of Error

1. Leakage.—The containers and their connections must be air tight. Before mounting, they are tested separately by filling with air under pressure and immersing in water. The assembled apparatus will indicate leakage by a steady fall of the mercury column when the air is partially evacuated.

All tube connections are made with heavy rubber pressure tubing and are sealed with red lead paste, bound with a double loop of wire belt lacing, and coated with shellac.

2. Manometer.—The manometer scale is graduated in millimeters but readings are estimated to 0.1 millimeter. The effect of 0.1 millimeter error in observation, when testing an average brick, was found to be 0.20 cubic centimeter for R_1, and 0.44 for R_2. Consecutive tests of pore space usually agree within 1 cubic centimeter, which indicates that readings may be taken within limits of significant error.

Inspection of formula (2) shows that $V_1^1R_2$ and V_2R_2 become indefinite when R_2 approaches zero. For this reason, readings near zero on the manometer scale are avoided.

The mercury column in the manometer usually comes to a constant level in less than 60 seconds, but in some cases a longer time is required. The causes of such variation have not been definitely ascertained, but apparently depend upon the type of brick tested, or the nature of the brick structure.

3. Thickness of Rubber Gasket.—A slight error may be caused by differences in pressures applied in adjusting the gasket and by variations in thickness incident to usage. Careful observations from time to time show this error to be inappreciable, when gaskets are changed frequently.

4. Moisture.—Washburn and Footitt[2] noted that exact results require freedom from adsorbed moisture in the test piece. Tests made by them indicate that this is not practically attainable, but that the volume of water content is insignificant when the test piece is carefully dried. Under atmospheric conditions, however, it was shown that an appreciable volume of pore space might be occupied by adsorbed moisture.

Another source of moisture is from the air of the auxiliary air container. To study its effect, a train of absorption tubes of sulphuric acid and calcium

[1] This corresponds to the formula, $P = \frac{W - D}{W - S} \times 100$, which was derived by Purdy and presented in *Trans. Amer. Ceram. Soc.*, **9**, 211 (1907).

[2] "Porosity III. Water as an Absorption Liquid," *Jour. Amer. Ceram. Soc.*, **4** [12], 965–69 (1921).

chloride was attached to the air inlet tube. The pore volume indicated was about 5 cubic centimeters lower with air thus dried.

The lower values due to moisture occupying pore space in the test piece tend to offset the higher values due to moisture from the auxiliary air. Experimental tests indicate that sufficiently accurate results for most purposes are obtainable with both the test brick and the auxiliary air under atmospheric conditions. For refined work, both the test piece and the auxiliary air should be dried.

5. Temperature and Pressure Effects.—The atmospheric temperature and pressure should be constant between readings, and the test brick and the containers should be in temperature equilibrium. The error effected by a difference of 1°C between containers at 20°C is $\frac{1}{273 + 20} \times 1000$, or 3.4 cubic centimeters. It is important, therefore, that the room in which the porosimeter is used, be not subject to temperature fluctuations, and that the bricks tested be at the temperature of the room.

Comparative Tests

Below are given the results of comparative tests of porosity and specific gravity upon two series of brick, which indicate the efficiency of the porosimeter method of determining porosity.

TABLE I

Heat Treatment	Per cent Porosity			Specific Gravity		
				Calculated from porosity		
	Water absorption	Porosimeter	Calculated from true sp. gr.	Water absorption	Porosimeter	True
Series 1						
Silica brick						
Soft-burned	23.67	25.37	25.40	2.394	2.444	2.445
Medium-burned	23.29	26.20	26.26	2.264	2.363	2.365
Hard-burned	24.90	26.80	26.82	2.292	2.321	2.321
Series 2						
Fire clay brick						
Soft-burned	21.91	22.84	22.84	2.667	2.694	2.694
Medium-burned	20.50	21.19	21.44	2.635	2.653	2.661
Hard-burned	12.61	15.68	16.00	2.564	2.651	2.661

A full report on the results of comparative tests on different types of refractory brick will appear in a subsequent issue of this *Journal*.

CERAMIC EXPERIMENT STATION
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BACTERIAL GROWTH IN ENAMEL SLIP[1]

By Joel G. Wahlin

Introduction

While engaged upon some chemical research relative to the manufacture of enamel, R. D. Cooke[2] observed the production of gas in enamel slip water. This was brought to the attention of E. W. Tillotson,[3] and was referred by him for solution to N. P. Sherwood.[4] After carrying out a few preliminary experiments he turned the biological aspects of the problem over to me for investigation.

Cooke observed that the production of gas in enamel slip water proceeded differently in the presence of various ions of the iron family, being most rapid with aluminum—iron, cobalt and nickel being next in order. He also observed that no reaction occurred in the absence of nitrates and acetates. These reactions took place at room temperature and the general nature of the phenomenon, its inhibition by heat, mercuric ion, and formaldehyde, was suggestive of bacterial action, which indeed it has proved to be.

The source of the microörganisms occurring in enamel slip is undoubtedly the clay used. This is indicated by the chemical composition of the enamel slip and the manner of its preparation. No living organisms could survive the temperature to which the enamel frit is subjected (2200°F) and it is therefore reasonable to suppose that contamination occurs upon the addition of clay. Moreover, enamel slip is at best a very poor culture medium for the growth of most bacteria and those that would occur there would of necessity be of an autotrophic nature in certain of their food requirements. Autotrophic bacteria are widely distributed in nature and their presence in clay could be accounted for by percolation of soil water. Owing to a lack of time no attempt has been made to isolate any organisms from clay and to see if such organisms would resemble those found in enamel slip. Such an investigation would not have fallen within the scope of the work as originally planned and has therefore been postponed for future study.

Assuming then that bacteria are carried into the enamel slip with the clay, what characteristics might one expect such organisms to possess? A consideration of the chemical and physical properties of clay might furnish a clue in answer to this question.

The bacteriology of clay is as yet largely an unsolved problem. The reason for this is that agriculturally clay is an unproductive soil and there

[1] Portion of a thesis presented to the University of Kansas in partial fulfilment of the requirements for the degree of Master of Arts. Presented at the Atlantic City Meeting, February, 1924. (Enamel Division.)

[2] Mellon Institute and the Columbian Enameling and Stamping Company.

[3] Assistant director of Mellon Institute.

[4] Head of the Department of Bacteriology of the University of Kansas.

has been no immediate need for a knowledge of the bacteria present. The rôle of bacteria in clay, from the standpoint of its application to the arts and industries, has not been touched upon to any extent. The physical and chemical composition of clay renders it unsuitable as a culture medium for the growth and development of many bacteria, a property which might be spoken of as a "selective action."

Among the chemical compounds occurring in clay, those most commonly met and which would be of importance to the living cell are: aluminum silicate, calcium carbonate, iron oxides, iron sulphides, phosphates, sulphates and the organic matter and nitrogen compounds. Clay is relatively poor in organic matter and the nitrogen occurring in it would probably be associated with the organic material or gain entrance by infiltration from the surface soil.

The substance of the clay is in a state of fine division generally, although there is a great variation in the size of the particles. Around the clay particles or filling the spaces between them is water and this water holds in solution those compounds utilized by bacteria. The paucity of nitrogenous and organic matter would be a factor in limiting bacterial types.

Discussion and Summary

Many denitrifying bacteria have been described in bacteriological literature. With respect to carbon such forms are mostly of the heterotrophic type, in that they require organic carbon for energy purposes. The denitrifier present in enamel slip is no exception to this rule but is characteristic in its inability to utilize carbohydrate. One would not expect to find carbohydrate substances in clay or enamel slip and consequently the organisms present would have to be able to utilize other organic substances. In this case organic salts of certain types seem to serve the purpose.

The nitrate destruction by this organism seems to proceed in two stages. (1) Reduction of nitrate to nitrite. (2) Reduction of nitrite to a gaseous nitrogen. As pointed out before, the presence of peptone seems to favor the reduction of nitrite to ammonia. There may, however, exist the possibility that under these circumstances the ammonia appearing in the culture may be the result of the deaminization of amino acids, since the gas can also be formed in such media. The reduction of nitrate is probably the method of obtaining the necessary oxygen with which to oxidize the carbon. This view is supported by the fact, that under anaerobic conditions nitrate reduction is accelerated. The ability to grow in the absence of air would naturally be of advantage to the cell under anaerobic conditions in clay. In common with many bacteria it shares the ability to grow at lower temperatures. The original sample of slip from which these organisms were isolated, after standing at icebox temperature for a year and a half, contains the organisms in seemingly undiminished numbers.

The rôle of aluminum is not clearly defined. Cooke found that this element favored gas formation. It is probable that repeated cultivation of the organism away from this element, would tend to reduce its sensibility to it. Later work along these lines seems to indicate that manganese has a beneficial effect in this respect. The work done so far, however, points toward the fact that these substances are accessory rather than essential for growth and denitrification.

No symbiotic relationship was found between the pigmented organism and the denitrifier. A mixed culture did not augment growth and gasification. Moreover, the physiological reactions of the two organisms are so nearly parallel that no hint was given as to the possible mechanism of such a symbiosis.

As mentioned earlier in this paper clay and enamel slip by the very natures of themselves would tend to exert a "selective action" on types of bacteria. Such a "selective action" would account for the presence of only two species of bacteria in the sample analyzed and would also account for the relatively "simple" physiological behavior and food requirements of the microörganisms isolated.

A search through bacteriological literature on the classification of microorganisms has failed to reveal any organism identical with those described in this paper. Owing to the fact that the classification of soil bacteria is as yet in a rather unorganized state, I would hesitate to state that these organisms have not previously been described. Just what their position may prove to be in the great group of soil organisms is impossible to state at the present time.

Conclusions

We can conclude therefore that:

1. Enamel slip is not sterile, as evinced by the isolation of two different microörganisms from a sample.
2. One of these organisms is capable of producing gas in the enamel slip by decomposing nitrates present.
3. A strong alkaline reaction is necessary for growth and denitrification by the organism.
4. Metallic ions exert an influence on the rate of denitrification, but are accessory rather than indispensable to the process as well as growth of the cell.
5. There is no symbiotic relationship between the two organisms studied.

I wish to acknowledge my indebtedness to Professor Sherwood for his council and help throughout the work and to Mr. Cooke for the chemical data which led up to this work and his kindness in furnishing the samples of enamel slip.

LAWRENCE, KANSAS

THE OXIDATION OF CERAMIC WARES DURING FIRING.—I. SOME REACTIONS OF A WELL KNOWN FIRE CLAY[1]

By George A. Bole[2] and Frederick G. Jackson[3]

ABSTRACT

After a review of the literature, a chemical laboratory study is made of the gases evolved on heating a lower Kittanning fire clay at various rates to various temperatures in a current of pure oxygen. The rates of evolution of CO_2, SO_2, and SO_3 are determined under varying conditions. Determinations of the remaining sulphur in the clay after heating are made. Possibilities as to the chemical mechanism of sulphur evolution are suggested. Plans for continuation of the work are outlined.

Introduction

The purpose of this investigation[4] is an endeavor to compile fundamental data that may ultimately lead to a clarification of the several special problems that have presented themselves during the industrial kiln investigations which have been carried out by the Bureau of Mines under supervision of the Joint Research Committee of the Four Heavy Clay Products Associations.

The work will first be carried out in a laboratory way, after which commercial conditions will be investigated.

The first phase of the investigation will be a study of the three fundamental variables which govern the oxidation of ceramic bodies, namely: time, temperature, and atmosphere. The bathing atmosphere is to be varied from pure oxygen to pure nitrogen. Carbon dioxide, hydrogen, and methane will also be introduced in some cases.

With this fundamental data in hand, it is hoped to start the investigation of some of the special problems which confront the ceramist during the firing of ceramic ware.

Previous Work

H. A. Seger laid the foundation of the study of these problems. He conducted interesting qualitative experiments on the effect of oxidizing and reducing gases,[5] both with and without an admixture of sulphur-bearing gases on the color of four familiar types of clays, when fired to various temperatures. He also[6] made a thorough quantitative study of the ratio of carbon, hydrogen, oxygen, and nitrogen in the gases of various kilns at all stages of the burn. He pays little attention to sulphur in the clay throughout his work. He states, however, that sulphurous gases

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[4] This paper is the first of a series on "The Oxidation of Ceramic Wares during Firing."

[5] "Collected Writings," **1**, p. 106.

[6] *Ibid.*, **1**, p. 135.

passing through a kiln will combine with calcium carbonate to form calcium sulphate and thus prevent the iron from forming a yellow colored ferrous-calcium silicate. The iron is thus left, uncombined with silica, to oxidize. The ferric oxide colors though were a darker, more reddish color. According to him, magnesia and probably alumina act like calcium carbonate in this respect. Throughout his writings, he returns frequently to this subject and produces several comparative analyses[1] in support of this theory. As his data accumulates, he speaks[2] definitely of "a silicate consisting of iron oxide, alumina, lime and silica." He mentions[3] among occasional sources of efflorescence on brick, the salts of iron, chromium, and vanadium.

At the second meeting of the AMERICAN CERAMIC SOCIETY, W. H. Zimmer[4] stated that water steam is strongly oxidizing. It may convert the sulphur in kiln gases to H_2SO_4, this will convert lime to $CaSO_4$, which will persist to high temperatures.

Edward Orton, Jr.,[5] explained "black core" in brick as due to ferrous iron formed by the reducing action of organic matter. The same statement appeared in *Tonindustrie Zeitung*[6] for the same year. Hopwood and Jackson[7] quote this paper and state that this is due principally to carbonaceous matter in the clay, which, by reason of an insufficient air supply, has been given no opportunity for oxidation; but that the effect of this agent is modified by ferrous oxide, ferroso-ferric oxide, and occasionally by sulphide of iron.

G. C. Matson produced evidence[8] to the effect that black color is due to FeO without carbon being necessarily present.

Hopwood[9] notes that ferric oxide can be changed to the magnetic oxide by prolonged ignition at white heat, but does not believe that this happens in kiln practice. He found no magnetic oxide in tiles heated under oxidizing conditions to 1350°C. In the discussion of this paper, Dr. Jackson stated that he thought that bloating at complete vitreousness was probably due to the formation of a ferrous silicate from ferric and siliceous fluxes. "Was it possible," he said, "that the blisters which form at the same time are due to the evolution of oxygen as the ferric passes into the ferrous on combination with the silicates?"[10]

[1] "Collected Writings," **1**, pp. 354, 355.
[2] *Ibid.*, **1**, p. 374.
[3] *Ibid.*, **1**, p. 382.
[4] *Trans. Amer. Ceram. Soc.*, **2**, 34 (1900).
[5] *Ibid.*, **5**, 407 (1903).
[6] *Tonind. Zeit.*, **1**, 432 (1903).
[7] *Trans. North Staffordshire Ceram. Soc.*, **2**, 100 (1902–3).
[8] *Clay Worker*, **42**, 44(1904).
[9] *Trans. Ceram. Soc.* (English), **3**, 37 (1903–4).
[10] Recent work would point to the greater likelihood of the blisters being due to decomposition of $CaSO_4$ with the evolution of SO_3.

Edward Orton, Jr., and his co-workers have developed the theory now held most generally. Beginning with a hint[1] as to the activity of sulphur, they published two masterful papers in which the whole situation was studied.[2] The general ideas developed are that, as a kiln is heated, there is an evolution of water, carbon dioxide, and sulphur dioxide from the ware. That this evolution must be allowed to run to completion below 900°C and also that all iron present must be oxidized below this temperature. That in some cases an evolution of combustible gas will raise the temperature above 900°, while itself reducing the iron. In such a case the kiln must be sealed and fires banked or drawn. That above 900°C the capillaries of the clay close, preventing the further evolution of gases.[3] That if ferrous iron remains in the center of the ware, a comparatively harmless but unsightly black core of ferrous silicate will persist. That carbon is completely eliminated by oxidation in the average ceramic burn before sulphur is burnt off. That the sulphur is in reality the principal culprit, acting as a reducing agent inside the brick. That the sulphur comes off in two stages, FeS_2 becoming FeS and SO_2 and then FeS burning through $FeSO_4$ to Fe_2O_3 and SO_2. That sulphur remaining in the brick above 900° C will cause swelling.

These conclusions were reached from a ceramic point of view. In the experimental work, various clays were made up into small brick. These were burned according to good and bad firing schedules in a laboratory kiln. The gases evolved were not studied, but the samples were studied as brick and only incidental chemical analyses were made.

Mellor[4] studied the evolution of sulphur from pyrite and marcasite by heating the powdered minerals in a gentle current of air to successive temperatures. He found 6.5% of the sulphur evolved at 400°, 32.3% at 500°, and 76.2% at 600°, etc. Even at 900° there was 6.6% of the sulphur of pyrite remaining. "The powdered minerals were stirred up and a portion withdrawn for analysis at the times stated." The conditions of this experiment were so different from the case of the mineral present as a small impurity in a clay that analogy should be drawn with caution. In describing the oxidation of these minerals, Mellor states that some ferrous sulphate is formed at low temperatures in excess of air and at higher temperatures ferric and basic ferric sulphates are produced. He

[1] Orton, *Trans. Amer. Ceram. Soc.*, **5**, 331 (1903).

[2] Orton and Griffin, "The Influence of Carbon in the Burning of Clay Wares," Second Rept. of Comm. on Tech. Investigation, National Brick Manufacturers' Association (1905). Orton and Staley, "A Study of the Chemical Status of the Carbon, Iron, and Sulphur in Clays during the Various Stages of Burning," Third Rept. of same Comm. (1908).

[3] See J. M. Knote, *Trans. Amer. Ceram. Soc.*, **12**, 226 (1910).

[4] J. W. Mellor, *Trans. Ceram. Soc.* (English), **6**, 142 (1907); **7**, 112 (1908).

discusses the possible removal of pyrite by chemical, electro-magnetic, and electrostatic methods.

H. B. Wells[1] met his sulphur problem by experiments on a commercial kiln. Finding that kilns burning a high sulphur clay were producing very unsatisfactory ware, he tried drawing the fires at dull redness. Sulphides continued to burn and increase the temperature of the kiln till the center and bottom were overburnt. A forced draft of cold air did not help matters. Finally he drew fires at the first hint of sulphur fumes and opened the top of the kiln and closed the dampers. This let the sulphur in the upper part of the kiln burn off without heating the center and bottom. At the proper time the openings in the top were closed again, the dampers opened, and firing resumed. This greatly increased the uniformity of product.

Knollman[2] said that sulphuring during watersmoking seemed to be the main cause of pinholing in glazes, since it is possible to use a harder, more viscous glaze when the watersmoking period is reduced.

Stout[3] showed that iron sulphide nodules in clay were of secondary origin, and would start to form around a bit of carbon or any small grain that may start a crystalline growth.

Garve[4] said that with a limey clay, while some scum is formed in the drier, if it is burnt in a continuous kiln without advance heating flues the scumming will be worse. This can be diminished by finishing the burn under reducing conditions, thus driving off SO_3.

H. W. Hofman and W. Mostowitsch[5] showed that SiO_2 or Fe_2O_3 lowers the dissociation temperature of $CaSO_4$ to 1000° and 1100°, respectively.

A. E. Williams[6] studied the effect of atmosphere on the decomposition of calcium sulphate in a quantitative way.

J. G. Hay[7] mentions the catalytic power of colloidal clay in hydrogenizing oils, oxidizing organic compounds, etc. While far from the best catalyst, it has great advantages as a support for the real catalyst.

A. O. Jones[8] discusses the equilibrium and reaction velocity of the reaction $2SO_2 + O_2 \rightleftharpoons 2SO_3$, and reviews the work of Haber, Bodenstein, and Knietsch on this reaction.

Parmelee[9] gives a good résumé of the literature with impartial interpretation.

[1] "A Method of Overcoming the Sulphur Problem," *Trans. Amer. Ceram. Soc.*, **11,** 93 (1909).

[2] *Trans. Amer. Ceram. Soc.*, **17,** 165 (1915).

[3] *Ibid.*, **17,** 586 (1915).

[4] *Ibid.*, **17,** 600 (1915).

[5] *Trans. Inst. Min. Eng.*, **39,** 628.

[6] *Trans. Amer. Ceram. Soc.*, **17,** 764 (1915); **18,** 271 (1916).

[7] *Chem. Age*, **2,** 194 (1920).

[8] *Chem. Trade Jour.*, **69,** 183 (1921).

[9] "Soluble Salts in Clay Wares," *Brick and Clay Rec.*, Aug. 22, Sept. 2, **1922.**

Method of Attack

It was thought that an attack on the problem from a chemical point of view might open up the subject from a different angle.

The work was accordingly undertaken as a purely chemical research with only such incidental ventures into ceramics, in order to obtain fundamental data, as would serve to connect the work with the ceramic industry.

A well known fire clay was selected to begin with. This was the Lower Kittanning clay, as used at Fallston, Pennsylvania, in the manufacture of face brick. It showed the following constituents on analysis:

Loss on ignition	7.07	Lime	0.26
Silica (SiO_2)	66.18	Magnesia (MgO)	.47
Alumina (Al_2O_3)	17.19	Potash (K_2O)	1.80
Ferric oxide (Fe_2O_3)	5.10	Soda (Na_2O)	.23
Titania (TiO_2)	1.48	Sulphur (S)	.28

A number of cylindrical bars were made, three quarters of an inch in diameter and about seven inches long. They averaged about 70 grams in weight. These bars were thoroughly dried at 110°C and then were cooled and kept in a desiccator. These bars would slip into a refractory tube in an ordinary Hoskins electric tube furnace.

Such a furnace seemed eminently fitted to begin the study of oxidation of clay. Any desired temperature up to 1100°C could be attained with rapidity and maintained with considerable accuracy for long periods without attention. Any atmosphere could be supplied to a bar of clay in the tube without contamination by fuel gases. Exit gases could be passed through appropriate absorption apparatus and the various compounds thus removed quantitatively.

According to Orton, as previously mentioned, the burning reactions result in the evolution of carbon dioxide, sulphur dioxide, sulphur trioxide, and water, and the formation of ferric oxide. The study of the progress of these first three reactions was first undertaken. The evolution of water will be considered in a following paper of this series. It was planned to conduct a series of tests with varying atmospheres, using pure oxygen, pure nitrogen, and mixtures of the two in varying proportions, as well as varying percentages of carbon dioxide. In the work described in this paper, pure oxygen alone was used in the belief that reactions which proceed sluggishly under firing practice would be greatly accelerated, but not changed in nature. Under these violent oxidizing conditions and in view of the fact that clay at certain temperatures is a catalyst for the reaction, we would expect the formation and evolution of sulphur trioxide as well as sulphur dioxide. The determination of water and carbon dioxide when so evolved is solid ground. A U-tube of granular calcium chloride and a

Liebig bulb filled with 20% caustic soda solution and provided with a small guard tube of calcium chloride are conventional. The gain in weight of these gives, respectively, the amounts of water and of carbon dioxide absorbed. The system was provided with a three-way cock between combustion tube and calcium chloride tube and two absorption trains were provided so that the current of gas could be switched from one train to another without loss at appropriate intervals and the used train could then be detached, weighed, and replenished. The combustion tube was drawn down at the exit end and made as short as possible, and the limbs of the three-way cock were shortened to the limit to cut down the cooler gas space. This was done so that the water vapor would not cool and condense and be held back, but would be collected as soon after it left the clay as was the carbon dioxide. Thus the course of gas evolution could be followed.

Oxygen was passed from a tank of compressed gas through 20% caustic soda and a calcium chloride tube to the combustion tube. Tubes for various temperatures and of varying lengths were made of Jena glass, Pyrex glass and fused quartz.

All experiments of this series were started with the furnace cold. A bar of clay was weighed and put into the middle of the combustion tube. A noble metal thermocouple connected to a potentiometer was inserted between tube and furnace, oxygen turned on, rheostat set for the desired temperature, and the heating circuit completed. After an hour the current of exit gas was switched to the other train. The used train was then weighed and renewed. The train was changed every half hour at lower temperatures, every twenty minutes at higher temperatures, until the bulk of gas evolution had ceased. This rapid changing was kept up for from two and a half to four hours. During the rest of the day, the trains were changed at longer intervals and the last one was left on all night.

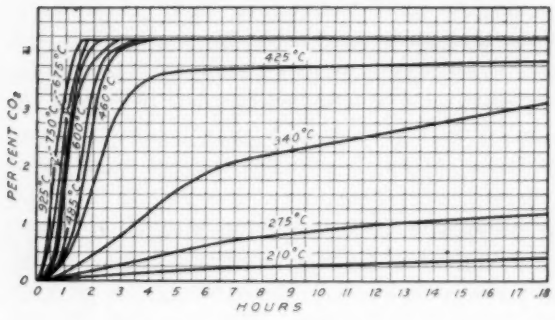

FIG. 1.

Evolution of Carbon Dioxide

The evolution of carbon dioxide is shown in Fig. 1. A very little is given off at low temperatures. The amount increases rapidly with the

temperature to a definite maximum. The only difference at higher temperatures is that the maximum is reached sooner. This must be formed by the burning of carbon in the clay. Carbon may be present either as an impurity of real coal, or the clay may be a low-grade oil shale, or both.

Carbon dioxide present as carbonate in the clay was also determined by heating a weighed amount of clay in a flask with sulphuric acid and passing the gases evolved through a $CaCl_2$ tube and a weighed soda bulb. The gain in weight corresponded to 0.145% CO_2.

Evolution of Sulphur

Sulphur is also being given off, both as dioxide and as trioxide. The sulphur dioxide is all absorbed in the caustic soda solution and was determined without difficulty. Sulphur trioxide, however, is not so accommodating. It combines with water to form a sulphuric acid mist. A little of this mist may be absorbed by the wet grains of calcium chloride. Much of it is dissolved by the caustic soda solution, but traces may pass on out and be lost if its concentration is high. This can be seen, in extreme cases as a white smoke issuing from the soda bulb. Its absorbtion will be taken up in the following paper of this series. After each used caustic soda bulb had been weighed for carbon dioxide absorbed, it was washed out into a 100-cc. graduated flask and refilled with fresh caustic soda. The spent solution, containing carbonate, sulphite, and sulphate, was diluted to 100-cc. volume and divided into two equal portions. One of these portions was promptly neutralized with a slight excess of hydrochloric acid, boiled to expel the last traces of CO_2 and SO_2, and then precipitated with $BaCl_2$ solution. This brought down all of the H_2SO_4 formed from sulphur trioxide as $BaSO_4$. After standing over night, this was filtered on an ashless paper, ignited to red heat in a weighed platinum crucible, and weighed. The other portion of spent solution was neutralized with a slight excess of nitric acid. Then either hydrogen peroxide or bromine water was added. It was thought that the bromine water was more efficient. Oxidizing gases were thus retained in solution as long as

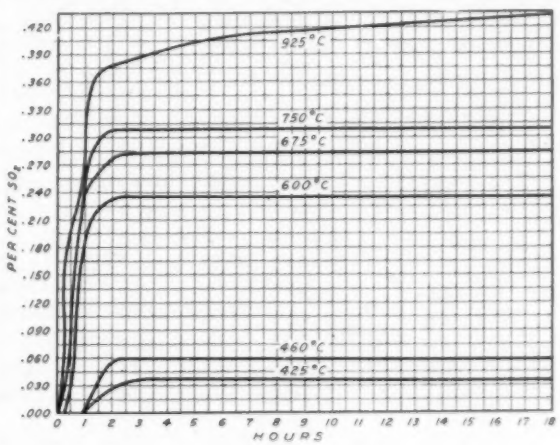

FIG. 2.

possible and all SO_2 was oxidized to SO_3. What was expected to be a slight excess of barium nitrate solution was then added. The solution was heated to boiling and boiled until colorless. More barium nitrate was then added to make sure that all of the sulphur was precipitated as $BaSO_4$. This was determined as in the previous case. Thus the weight of SO_3 and of $SO_2 + SO_3$ present were calculable. By subtraction, the weight of SO_2 was found. The weight of SO_2 and of SO_3 found in each caustic soda bulb was subtracted from the gain in weight of the bulb to give the actual weight of CO_2 present. No correction was applied to the $CaCl_2$ tubes, since the very small amount of H_2SO_4 mist absorbed practically equalled the amount of water carried on by the SO_3 as H_2SO_4.

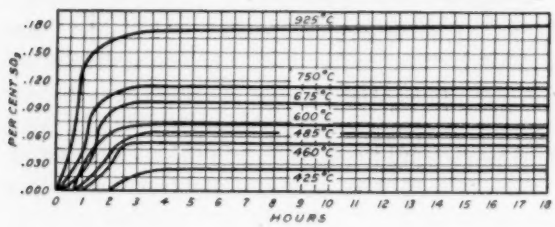

FIG. 3.

While it is thus shown that the values for sulphur found in this series of experiments do not tell quite the whole truth, still it was necessary to determine them in order to determine CO_2 and they throw much light on the subject. The figures are given below to give a close approximation of the sulphur evolved:

Temperature °	Per cent SO_2	Per cent SO_3	Per cent total S	Ratio $\frac{SO_2}{SO_3}$
340	none	none	none	none
425	none	0.0239	0.0096	0
460	0.0308	0.0500	0.0354	0.62
486	0.0574	0.0627	0.0538	0.92
500	0.0486	0.0882	0.0596	0.55
600	0.2333	0.0710	0.1450	3.29
675	0.2823	0.0954	0.1793	2.96
750	0.3090	0.1144	0.2003	2.70
925	0.4320	0.1818	0.2887	2.38

Curves are shown, Figs. 2 and 3, illustrating the rate at which SO_2 and SO_3 are evolved. It will be noticed that, except at the highest temperature no sulphur was evolved after four hours of heating. The interpretation of these results will be taken up later.

Sulphur Evolved at Varying Rates of Heating

Another line of experiment was now tried. A bar of clay was heated for four hours to 390°, then the temperature was raised to 570° for four hours and then raised to 675° for four hours more. In this test two soda bulbs were alone used in series, no calcium chloride tube, and the bulbs were changed just before the temperature was raised each time. The

evolution of sulphur gases was so slow that there was never any sulphur in the second bulb. Absorption in the first was, therefore, as complete as NaOH would absorb. The total amount of sulphur evolved was as follows:

Temperature °	Per cent SO_2	Per cent SO_3	Per cent S	Ratio $\frac{SO_2}{SO_3}$
390	none	0.0184	0.0074	0
570	0.0283	0.0935	0.0515	0.30
675	0.0589	0.1075	0.0724	0.55

This shows that only 0.724% of sulphur was given off in this whole 12 hours heating up to 675° while in the previous test to the same temperature 0.1793% was evolved. Notice also that in the normal test the SO_2:SO_3 ratio is about 3.0 and in the slowly increased temperature this ratio is 0.55. The slow evolution of gas in the presence of pure oxygen would account for this excess of SO_3.

The third series of experiments was made also on this subject. A bar of clay was heated to 505° for four hours and the sulphur gases caught and analyzed as before. A new soda bulb was then put on and a new bar of clay was placed in the hot tube in addition to this first bar and oxygen passed for four hours more. Sulphur gases were again collected and determined. The furnace was cooled and the bars removed. It was then heated empty to 505°, oxygen passed till the air was displaced, a soda bulb put on and a weighed bar of clay inserted in the tube. A stream of oxygen was passed for four hours and the sulphur gases caught and analyzed as before. The results were as follows:

State of furnace at start	Temperature °	Per cent SO_2	Per cent SO_3	Per cent S	Ratio $\frac{SO_2}{SO_3}$
Cold, empty	505	0.0862	0.0538	0.0646	1.6
Hot, one bar in	505	0.1259	0.0272	0.0738	4.6
Hot, empty	505	0.1984	0.1226	0.1482	1.6

These figures are astounding. More than twice as much sulphur is given off in the third case as in the first. Yet the ratio of SO_2:SO_3 is the same. The only difference between the cases was the rapidity with which the clay was heated. Therefore, this increase in evolved sulphur must be due to this cause. As much sulphur must have been evolved from the second bar as from the third, since conditions were identical. The only place that the sulphur could have disappeared to was into the first bar, which was still in the furnace. This first bar must then have absorbed the amount of sulphur equal to the difference between that given off by the second and that given off by the third bar. This difference, .0744% S, is greater than the amount of sulphur previously evolved by the first bar. The investigation of this question called for a fourth series of experiments.

Analysis of Clay Bars

A typical series of partly burned clay bars was selected for analysis. No. 1 had been dried at 110°, but had had no other heat treatment. No. 2 had been heated to 485° for 20 hours. No. 3 had been heated to 505° for eight hours. During four of these hours there was another bar behind it. No. 3 was the first case in the previous experiment. No. 4 had been put into a preheated furnace and held at 505° for four hours. It was the third case in the previous experiment. No. 5 had been heated to 600°, No. 6 to 675°, No. 7 to 750° and No. 8 to 925°, each for approximately twenty hours in oxygen. Ten grams of each body were finely ground, accurately weighed, and then boiled with 150 cc. distilled water for half an hour. On settling, the water was poured off and the clays washed twice by decantation. The water and washings were then analyzed for sulphur. The clays were boiled for half an hour more each with 150 cc. of 1–5 hydrochloric acid solution. This was in turn poured off, the clays each washed twice, and the washings and acid solution tested as before. The clays were then boiled with 1–3 nitric acid and the process repeated. Sulphur was determined as $BaSO_4$, as in the previous work.

			Cold start	Hot start				
T° of previous heating	110°	485°	505°	505°	600°	675°	750°	925°
Per cent S evolved by heat	none	0.0538	0.0646	0.1482	0.1450	0.1793	0.2003	0.2887
Per cent S dissolved by water	0.040	0.129	0.238	0.150	0.097	0.046	0.034	0.007
Per cent S dissolved by 1–5 HCl	none	0.116	0.059	0.006	0.050	0.041	0.026	0.001
Per cent S dissolved by 1–3 HNO_3	none	none	none	none	none	none	none	none
Total per cent S found	0.040	0.299	0.362	0.304	0.292	0.266	0.260	0.297

Discussion of Results

In the case of the raw clay, most of the sulphur remains undissolved, as pyrite. The soluble sulphur may be referred to sulphates of alkalies, alkaline earths, or iron. In the second case, as much sulphur was found evolved or dissolved as in the other normal cases. This shows that the reaction

$$FeS_2 + O_2 = FeS + SO_2 \text{ or } 2FeS_2 + 3O_2 = 2FeS + 2SO_3 \qquad (1)$$

has proceeded to completion. FeS is insoluble in water, but soluble in HCl solution. It will be noticed that the amount of sulphur extracted by HCl solution is less the higher the temperature. This means that the FeS has been changed by oxygen and heat in one or more of the following ways:

$$\begin{aligned} 4FeS + 7O_2 &= 2Fe_2O_3 + 4SO_2 \\ 4FeS + 9O_2 &= 2Fe_2O_3 + 4SO_3 \\ FeS + 2O_2 &= FeSO_4 \\ 2FeS + 5O_2 + SO_2 &= Fe_2(SO_4)_3 \end{aligned} \qquad (2)$$

There is also a possibility of a direct oxidation of pyrite:

$$\begin{aligned} 2FeS_2 + 7O_2 &= Fe_2(SO_4)_3 + SO_2 \text{ or} \\ 4FeS_2 + 15O_2 &= 2Fe_2(SO_4)_3 + 2SO_3 \\ FeS_2 + 3O_2 &= FeSO_4 + SO_2 \\ 2FeS_2 + 7O_2 &= 2FeSO_4 + 2SO_3 \end{aligned} \qquad (3)$$

To this particular clay, about 5% of iron as mill scale had been added for commercial purposes. This iron, when hot and wet with evolved water of constitution, will readily absorb SO_2 and SO_3 to form sulphate:

$$\begin{aligned} Fe + SO_2 + O_2 &= FeSO_4 \\ 2Fe + 2SO_3 + O_2 &= 2FeSO_4 \\ 2Fe + 3SO_2 + 3O_2 &= Fe_2(SO_4)_3 \\ 4Fe + 6SO_3 + 3O_2 &= 2Fe_2(SO_4)_3 \end{aligned} \qquad (4)$$

Either gas may form either sulphate. These sulphates form the sulphur dissolved in water. Their amount decreases as the temperature increases, and they are decomposed by the reversing of the above reactions and the oxidation of the iron.

In the third case in the table above, this water soluble sulphur is very high since sulphur gases from a second bar of clay were also absorbed by the iron. That this has happened is proved by the fact that the total per cent of sulphur found is 20% above normal. In the fourth case above, the rapid heating formed very little ferrous sulphide. The action was so rapid that oxygen was probably scarce and the reaction taking least oxygen, namely that forming ferrous sulphate directly from pyrite, predominated. The SO_2 was generated so rapidly that comparatively little was taken up again by the iron, making a high yield of sulphur-bearing gases.

Conclusions

The following tentative conclusions would seem to be justified. Further work proving or disproving them, will be necessary before they may be considered final.

1. That carbon is burnt out completely by oxygen at 460°.
2. That it is burnt out more rapidly the more rapid the rate of heating.
3. That sulphur is evolved as dioxide and trioxide the more rapidly the faster and the higher the heating is carried out. Sulphur evolution is practically complete at 925°C after prolonged heating.
4. That at a temperature of 485° in oxygen the decomposition of FeS_2 appears to be complete.
5. That at temperatures of 505° and below, the principal source of

sulphur evolution seems to be the oxidation of FeS_2 to FeS, forming SO_3 and SO_2.

6. That while half of the total sulphur is thus dislodged at low temperatures and forms gases, much of these gases are again absorbed by impurities in the clay as sulphates.

7. That the amount of re-absorption of these gases is greater the more slowly they are evolved.

8. That the FeS formed by the decomposition of FeS_2 must further decompose to form either Fe_2O_3 and sulphur gases or else to form sulphate. The choice of action will depend on the rate of heating and the temperature attained.

9. That in an atmosphere of oxygen practically all FeS is oxidized one way or the other by a temperature of 500°.

10. That the decomposition of the remaining sulphates proceeds progressively to completion between 600° and 925°. Calcium sulphate is not considered in this connection.

Further work will develop more fully various phases of this entire subject and papers on the same general subject will be published from time to time. It is planned eventually to review them all and to tie up the loose ends in a general series of conclusions.

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COMBUSTION IN KILNS BURNING REFRACTORY WARE[1]

By Ralph A. Sherman[2]

ABSTRACT

The results are presented of a study of the process of combustion in kilns burning refractory wares, using coal as fuel. The work was undertaken in connection with the investigation of burning problems in the manufacture of refractories, conducted by the Bureau of Mines in coöperation with the Refractories Manufacturers Association.

Combustion in a Kiln

In a brick kiln the coal is burned in a number of fire-boxes placed about the periphery. The coal may be supported on inclined or flat grate bars or may rest on the bottom of the fire-box as in the "dead-bottom" type. Doors to close the opening through which the coal is fired are not commonly used, the fresh charges of coal filling this opening. The firing opening thus serves as an additional grate area.

The combustion of coal in a fuel bed takes place in three stages. The first stage is the union of the oxygen of the air with the carbon of the coal to form carbon dioxide. This reaction is very rapid and takes place in the first few inches from the point of air admission. The second stage is the union of the carbon dioxide, so formed, with more carbon to form carbon monoxide. The third stage is the distillation of the volatile matter from the freshly fired coal at the top of the fuel bed. The volatile matter leaves the fuel bed in the form of various gaseous hydrocarbons and tar. Thus the fuel bed is divided into three zones which, however, are not distinct, but overlap.

The gases arising from a fuel bed, therefore, are carbon dioxide, nitrogen, carbon monoxide, hydrogen, methane, and other hydrocarbons, together with solid tar and soot. It has been shown[3] that no oxygen can pass through a level incandescent fuel bed 4 to 6 inches thick. The fuel beds in the furnaces of brick kilns are ordinarily carried at a thickness of from 18 inches to 3 feet. Therefore, oxygen must be admitted to burn the combustible arising from the fuel bed. This oxygen comes through the cool and thin bed of coal at the firing opening and through "eyes" in the wall above the fire-boxes.

The reaction of oxygen with the gaseous combustibles to form carbon dioxide and water is much less rapid than with solid carbon as in the fuel bed but will take place quickly if the gases are thoroughly mixed and

[1] Published by permission of the Director, U. S. Bureau of Mines. Presented at the Atlantic City Meeting, February, 1924. (Refractories Division.)

[2] Assistant Physicist, Pittsburgh Experiment Station, Bureau of Mines.

[3] Henry Kreisinger, F. K. Ovitz, C. E. Augustine, "Combustion in the Fuel Bed of Hand-Fired Furnaces," Bur. Mines, *Tech. Paper* **137**, 9 (1917). The reader is referred to this paper for a thorough discussion of the process of combustion in the fuel bed.

a high temperature is maintained in the combustion chamber. The more thorough the mixing the lower is the excess of air required for complete combustion of the gases in a given distance.

The complex gaseous compounds of carbon and hydrogen and the tar may burn to carbon dioxide and water directly without decomposition if they are distilled in the presence of oxygen. In the absence of oxygen they will be decomposed by the heat of the furnace into simpler compounds with the liberation of free carbon or soot.

Although the reaction between these carbon particles and oxygen is that of a solid and a gas it is extremely slow. This is doubtless due to the fact that the light particles are carried along in the gas stream at practically the same velocity as the gas. There is no scrubbing action of the gas on the surface of the particle and thus any carbon dioxide formed remains around the particle as a protective film through which oxygen for further combustion can penetrate only by the slow process of diffusion. Therefore free carbon will persist unburned for a great distance even in the presence of a considerable excess of oxygen over the amount theoretically required for combustion. These incandescent carbon particles give the flame its luminosity.

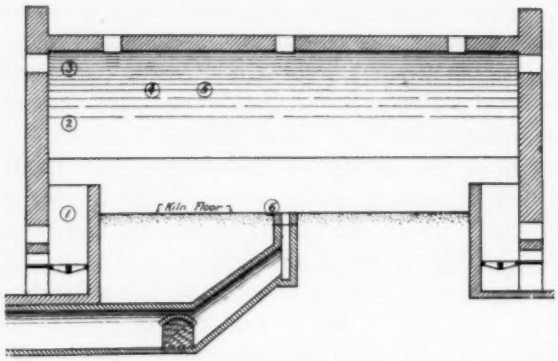

FIG. 1.—Section of rectangular kiln. Circles indicate position of samples.

If large amounts of combustible gases could be formed in the furnaces of a brick kiln and their combustion delayed until they approached the center and bottom of the setting less heat would be liberated near the rims and top of the ware and over-burning avoided while more would be liberated near the points which are difficult to heat. Thus a more uniform temperature would be attained throughout the kiln.

The purpose of this investigation was to determine, by the sampling and analysis of the gases along their path of travel through the kiln, the extent of the combustion zone in a kiln.

Scope of Investigation

The investigation was conducted on two types of kilns: (1) A rectangular, end-fired, down-draft kiln with one central transverse flue, commonly known as the "Newcastle" kiln. (2) A round down-draft kiln with fully

perforated bottom. The leading dimensions and particulars of these kilns are given in Table I.

Samples were taken during two successive burns on each kiln. Some changes in the setting and the method of firing were adopted for the second burn as were deemed advisable from observations on the first burn.

Method of Investigation

Water-cooled gas samplers were inserted in the kilns at the positions shown in Figs. 1 and 2. These positions were selected as representative

TABLE I

DIMENSIONS AND PARTICULARS OF KILNS

General particulars	Units	Kiln	Kiln
1. Type of kiln		Rectangular end-fired	Round
Kiln Dimensions			
2. Inside	Ft.-in.	16–6 x 30–6	Diameter 25 ft.
3. Height to top of crown	Ft.-in.	10–4	15–6
Furnaces			
4. Type		Flat grates	Dead bottom
5. Number		6	10
6. Dimensions			
(*a*) First burn	Inches	22 x 30	23 x 40
(*b*) Second burn	Inches	36 x 30	.....
7. Area poking door	Sq. in.	198	.....
8. Effective grate area			
(*a*) First burn	Sq. in.	858	391[1]
(*b*) Second burn	Sq. in.	1278	.....
9. Area firing opening	Sq. in.	308	207
10. Ratio firing area to effective grate area			
(*a*) First burn		0.36	0.53
(*b*) Second burn		0.24	.....
Stack Dimensions			
11. Cross-section	Inches	24 x 24	37 x 37
12. Height	Ft.	37	41
13. Capacity of kiln	Pieces	.....	.....
	9" equivalents	40,000	40,000
Time of Burn			
14. First burn	Hours	156	83½
15. Second burn	Hours	134½	80

[1] Area of ash pit opening.

positions and as possibly being in the path of the gas stream so that the progress of combustion could be followed from point to point.

The gases were drawn in a continuous stream by means of a motor driven pump and a portion of this stream was collected at a uniform rate by displacement over a saturated salt solution. The samples were drawn

simultaneously from the several positions over periods of from 10 minutes to one hour.

The composition of the samples was determined by analysis in an Orsat using mercury as the displacing fluid, the carbon dioxide, oxygen, carbon monoxide, hydrogen, and methane contents being determined.

The temperature of the gases in the furnace was determined by means of an exposed platinum, platinum-rhodium thermocouple. The other temperatures in the kiln are the temperatures of the ware near the points of sampling. The temperature and composition of the stack gases were taken from the regular data recorded during the burns. The stack gas samples were drawn during a half or one-hour period and were, therefore, not simultaneous with the samples drawn from the kiln.

The pressures were taken by means of an inclined draft gage attached to a pipe inserted in the kiln near the points of sampling.

The composition of the gas samples, the temperatures, pressures, and remarks are given in Table II.

Discussion of the Results

Rectangular Kiln.—The burning method followed during the first burn of this kiln was that of the usual plant practice. After the period of water smoking the fires were carried very heavy, varying from about two feet at the front of the fire-boxes to three feet or more at the back. The firing opening was more or less stopped with green coal according to the speed at which it was desired to raise the temperature.

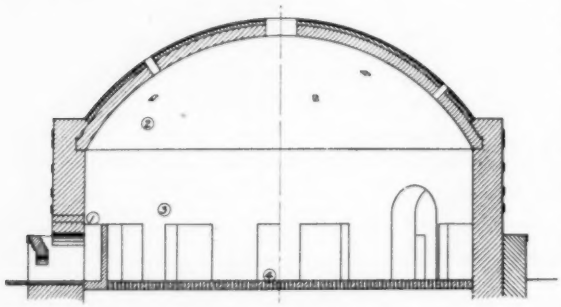

FIG. 2.—Section of round kiln. Circles indicate positions of samplers.

The gases at position 1, just above the fuel bed, were, in general, of higher oxygen content than those at position 2 indicating that this sampler was in an air stream coming through the firing door and that the gases passed upward farther toward the setting. An appreciable content of combustible gases was found in but one set of samples, set 4, at this position and this had almost completely disappeared at position 2. The presence of small amounts of carbon monoxide in the samples from other positions is probably owing to the fact that for a few minutes after firing there was insufficient air admitted to completely burn the gases. As the samples were drawn over a half-hour period the carbon monoxide appeared as

small percentages in the sample. This also explains the presence of appreciable amounts of this combustible gas together with oxygen in the samples taken from the stack when they were drawn over periods of one hour.

For the second burn on this kiln the setting was opened somewhat, the grate area was enlarged, and steel plates were hung over the firing openings to reduce the excess air during the water smoking period. These temporary doors were effective as is shown by the lower excess air in samples of set 1 than in those of a corresponding period in the first burn. Later, however, they became warped by the heat and were less effective in reducing excess air than stoppage of the openings by green coal.

The second set of samples was taken during the first ten minutes after firing. The sample from position 1 contained but 0.6% of oxygen with 2.5, 2.6, and 1.0% of carbon monoxide, hydrogen, and methane, respectively. The combustible content of the gases is lower at position 2 showing that oxygen has been supplied in addition to that present at position 1. This doubtless came from the other fire-boxes. Additional air met the gas stream to reduce the combustible content at the top of the kiln, position 4, and at the bottom center there is practically no combustible and an excess of oxygen. The significance of these samples is the very rapid combustion of carbon monoxide in the kiln when supplied with the necessary amount of oxygen.

The samples of sets 6, 7, 8, and 9, which cover a firing cycle of $1^3/_4$ hours, together with furnace gas temperatures, show very clearly the changing conditions in the kiln during the cycle. Immediately after firing there is a very heavy evolution of volatile matter giving in the furnace gases 10.4 and 8.0% of carbon monoxide and hydrogen, respectively, which are reduced before position 2 by an additional air supply to 6.0 and 2.8%. In the following half-hour period the combustible gases were greatly diminished and the carbon dioxide content in the furnace gases had risen to 15%. During the next two periods the coal which had stopped the firing doors had burned down admitting a greater supply of air and the combustible consequently disappeared and the carbon dioxide decreased.

The furnace gas temperatures follow the gas composition very closely. Shortly after firing, the temperature was low, 2274°, owing to the deficiency in air supply, then, as the air supply increased, rose to a maximum of 2529°, 40 minutes after firing, then fell to 2159° owing to the increasing excess of air.

During the period covered by sets 10, 11, 12, and 13, the fires were carried more open and the gas composition and temperatures were more uniform than when the fires were tightly closed on firing.

The pressure at any point in the kiln, except immediately above the fire-boxes and at the bottom of the kiln, was greater than that of the air at the same level.

TABLE II

RESULTS OF INVESTIGATION, RECTANGULAR KILN, FIRST BURN

Set no.	Hour of burn	Time of sample	Position of sample	Composition of gas						Temp., °F	Pressure in water	Remarks
				CO_2	O_2	CO	H_2	CH_4	N_2			
			1	1.7	17.5	0.0	0.0	0.0	80.8	..	....	
		10.40 A.M.	2	2.4	16.5	0.5	0.0	0.0	80.6	..	....	Fired 10:30 A.M.
1	17	to	3	3.8	15.4	1.4	0.0	0.0	79.4	..	....	6″–8″ below arch
		11:40 A.M.	4	3.5	15.8	0.4	0.0	0.0	80.3	521	....	
			5	3.9	14.7	0.3	0.0	0.0	81.1	..	....	
			6	3.6	15.0	0.0	0.0	0.0	81.4	298	....	
			Stack	5.6	13.8	0.0	0.0	0.0	80.6	171	−.054	
			1	5.7	13.4	0.4	0.0	0.0	80.5	..	....	
		9:40 A.M.	2	10.8	7.6	0.4	0.0	0.0	81.2	..	....	Fired 9:30 A.M.
			3	12.0	6.2	0.4	0.0	0.0	81.4	..	....	1″–3″ below arch
2	40	to	4	13.2	5.8	0.0	0.0	0.0	81.0	1489	.036	
			5	12.2	6.3	0.2	0.0	0.0	81.3	..	.034	
		10:30 A.M.	6	12.5	6.3	0.0	0.0	0.0	81.2	958	−.012	
			Stack	12.8	6.2	0.0	0.0	0.0	81.0	569	−.150	
			1	5.0	13.3	0.2	0.0	0.0	81.5	..	....	
		9:20 P.M.	2	6.8	11.9	0.0	0.0	0.0	81.3	..	....	Cleaned fires
			3	6.2	13.0	0.2	0.0	0.0	80.6	..	....	8–9:20 P.M. fired
3	51	to	4	8.4	9.9	0.1	0.0	0.0	81.6	1543	....	close up to arch
			5	8.3	9.7	0.0	0.0	0.0	82.0	..	....	
		9:50 P.M.	6	8.0	8.8	0.3	0.0	0.0	82.9	1198	....	
			Stack	8.6	10.2	0.2	0.0	0.0	81.0	725	−.190	
			1	12.1	1.9	7.0	1.6	1.5	75.9	..	−.045	
		10:45 A.M.	2	15.9	2.4	0.3	0.0	0.0	81.4	..	.022	Fired 10:30 A.M.
			3	16.4	1.1	0.9	0.3	0.0	81.2	..	.020	fired close up to arch
4	65	to	4	17.8	0.2	0.4	0.0	0.2	81.6	1947	.000	
			5	17.3	0.6	0.3	0.2	0.0	81.6	..	.001	
		11:15 A.M.	6	17.6	0.3	0.5	0.2	0.2	81.2	1749	−.053	
			Stack	15.0	4.2	0.0	0.0	0.0	81.8	..	−.200	
			1	5.2	13.8	0.2	0.0	0.0	80.8	..	.071	
		2:45 P.M.	2	11.3	6.6	0.0	0.0	0.0	82.1	..	.028	Fired 2:30 P.M.
			3	13.1	4.0	0.2	0.0	0.0	82.7	..	.070	2″–4″ below arch

TABLE II (*Continued*)

5	69	to	4	12.9	3.2	0.2	0.0	0.0	83.7	2042	.021	
			5	12.4	4.3	0.2	0.0	0.0	83.1	..	.019	
		3:15 P.M.	6	14.7	1.1	0.0	0.0	0.0	84.2	1849	−.030	
			Stack	14.8	4.0	0.0	0.0	0.0	81.2	1052	−.200	
			1	9.5	9.0	0.0	0.0	0.0	81.5	..	.195	
		11:00 A.M.	2	12.1	6.0	0.0	0.0	0.0	81.9	..	.075	Fired 10:45 A.M.
			3	12.2	5.8	0.0	0.0	0.0	82.0	..	.070	3″–4″ below arch
6	89	to	4	..	..	...	...	...	..	..	....	North end fired close
			5	..	..	...	...	...	..	..	....	
		11:30 A.M.	6	..	..	...	...	...	..	..	....	
			Stack	14.2	4.8	0.0	0.0	0.0	81.0	1367	−.210	
			1	4.8	13.9	0.3	0.0	0.0	81.0	..	.095	
		2:45 P.M.	2	14.2	1.2	1.0	0.6	0.0	83.0	..	.030	Fired 2:30 P.M.
			3	11.8	4.0	0.2	0.0	0.0	84.0	..	.045	2″–3″ below arch
7	93	to	4	..	..	...	...	...	..	..	....	
			5	12.9	2.6	0.0	0.0	0.0	84.5	..	.030	
		3:15 P.M.	6	14.1	0.5	0.3	0.5	0.2	84.4	2116	....	
			Stack	13.4	5.4	0.0	0.0	0.0	81.2	1430	−.215	
			1	14.4	4.7	0.2	0.5	0.0	80.2	..	−.010	
		9:30 A.M.	2	15.5	4.1	0.0	0.0	0.0	80.4	..	.040	Fired 9:15 A.M.
			3	13.9	4.9	0.3	0.0	0.0	80.9	..	.090	close to arch
8	112	to	4	15.1	3.5	0.1	0.0	0.0	81.3	2203	.070	No. 4 and No. 5 samplers 1′
			5	14.4	3.8	0.0	0.0	0.0	81.8	..	.060	inside crown No. 6
		9:50 A.M.	6	14.6	3.2	0.0	0.0	0.0	82.2	2147	.020	7′ inside crown
			Stack	13.2	5.6	0.0	0.0	0.0	81.2	1595	−.210	
			1	11.1	7.0	0.0	0.0	0.0	81.9	..	−.025	
		10:50 A.M.	2	14.6	3.2	0.0	0.0	0.0	82.3	..	.035	Fired 10:30 A.M. close to arch
			3	14.5	3.4	0.0	0.0	0.0	82.1	..	.060	No. 4 sampler not in,
9	137	to	4	..	..	..	...	...	..	..	....	others as in set 8
			5	13.2	3.3	0.1	0.0	0.0	83.4	..	.040	
		11:15 A.M.	6	14.9	0.9	0.5	0.4	0.0	83.3	2193	.000	
			Stack	14.8	3.6	0.1	0.0	0.0	81.5	1813	−.220	

TABLE II

RESULTS OF INVESTIGATION (*continued*), ROUND KILN

First Burn

Set no.	Hour of burn	Time of sample	Position of sample	Composition of gas CO_2	O_2	CO	H_2	CH_4	N_2	Temp., °F	Pressure in water	Remarks
			1	7.6	11.7	0.4	0.0	0.0	80.3	..	....	Fired at 9:30 A.M.
		9:15 A.M.	2	11.6	6.8	0.2	0.0	0.0	81.4	1263	....	
1	42	to	3	14.5	4.8	0.0	0.0	0.0	80.7	..	....	
		9:30 A.M.	4	14.5	4.2	0.3	0.0	0.0	81.0	826	....	
			1	5.1	14.1	0.5	0.0	0.0	80.2	..	....	
		9:30 A.M.	2	11.4	7.7	0.0	0.0	0.0	80.9	..	+.038	
2	42	to	3	13.0	4.7	0.5	0.0	0.0	81.8	..	−.036	
		9:45 A.M.	4	15.8	2.6	0.3	0.0	0.0	81.3	..	−.072	
			Stack	13.1	5.1	0.0	0.0	0.0	81.8	583	−.255	Stack analysis 8:30–9:30
			1	13.2	2.3	2.7	1.1	0.0	80.7	..	....	Fired 3:00 P.M.
		3:00 P.M.	2	14.7	2.1	1.5	0.3	0.0	81.7	1723	....	
3	48	to	3	17.4	0.3	0.7	0.0	0.0	81.6	..	....	
		3:10 P.M.	4	13.9	4.0	0.2	0.0	0.0	81.9	942	....	
			1	13.0	5.4	0.2	0.0	0.0	81.4	..	....	
		3:15 P.M.	2	12.7	6.0	0.3	0.0	0.0	81.0	..	+.030	
4	48	to	3	13.3	6.6	0.0	0.0	0.0	80.1	..	−.045	
		3:25 P.M.	4	10.9	5.3	0.3	0.0	0.0	83.5	..	−.085	
			Stack	13.2	4.9	0.0	0.0	0.0	81.9	686	−.275	Stack analysis 2:30–3:30
			1	12.9	5.5	0.2	0.0	0.0	81.4	..	....	Fired 10:15 A.M.
		10:15 A.M.	2	12.9	5.6	0.0	0.0	0.0	81.5	1849	....	
5	67	to	3	12.6	6.1	0.2	0.0	0.0	81.1	..	....	
		10:30 A.M.	4	11.8	7.3	0.0	0.0	0.0	80.9	1692	....	
			1	12.1	6.5	0.0	0.0	0.0	81.4	..	....	
		10:34 A.M.	2	10.3	9.0	0.5	0.0	0.0	80.2	..	−.015	
6	67	to	3	11.5	7.1	0.0	0.0	0.0	81.4	..	−.066	
		10:45 A.M.	4	12.5	6.3	0.0	0.0	0.0	81.2	..	−.104	
			Stack	13.3	5.6	0.0	0.0	0.0	81.1	1122	−.370	Stack analysis 10:30–11:30

TABLE II (*Continued*)

Second Burn

			1	13.8	3.9	0.2	0.0	0.0	82.1	..	....	Cleaned fires
		7:00 A.M.	2	11.9	5.6	0.2	0.0	0.0	82.3	1226	....	6:30 A.M. to 6:55 A.M.
1	39	to	3	11.8	6.5	0.0	0.0	0.0	81.7	..	....	
		7:15 A.M.	4	10.1	7.7	0.0	0.0	0.0	82.2	515	....	
			1	11.9	6.7	0.2	0.0	0.0	81.2	..	−.022	Fired 7:15 A.M.
		7:15 A.M.	2	11.3	7.3	0.2	0.0	0.0	81.2	..	+.048	
2	39	to	3	9.9	8.8	0.2	0.0	0.0	81.1	..	−.020	
		7:30 A.M.	4	8.8	9.9	0.2	0.0	0.0	81.1	..	−.054	
			Stack	9.4	8.8	0.0	0.0	0.0	81.8	500	−.230	Stack analysis 7:15–7:45
			1	12.6	6.1	0.0	0.0	0.0	81.3	..	....	Fired 1:45 P.M.
		1:40 P.M.	2	10.0	9.5	0.0	0.0	0.0	80.5	1418	....	
3	45	to	3	11.8	7.8	0.0	0.0	0.0	80.4	..	....	
		1:50 P.M.	4	11.8	7.2	0.0	0.0	0.0	81.0	687	....	
			1	11.7	7.6	0.0	0.0	0.0	80.7	..	−.052	
		1:50 P.M.	2	7.2	12.4	0.0	0.0	0.0	80.4	..	+.031	
4	45	to	3	10.9	8.8	0.0	0.0	0.0	80.3	..	−.050	
		2:00 P.M.	4	9.1	10.2	0.0	0.0	0.0	80.7	..	−.095	
			Stack	10.1	9.3	0.0	0.0	0.0	80.6	643	−.275	Stack analysis 1:45–2:15
			1	15.0	4.5	0.6	0.0	0.0	79.9	..	....	Fired 8:45 A.M.
		9:00 A.M.	2	16.0	2.3	0.0	0.0	0.0	81.7	1962	....	
5	65	to	3	15.4	1.6	0.0	0.0	0.0	83.0	..	....	
		9:10 A.M.	4	15.3	2.6	0.0	0.0	0.0	82.1	1486	....	
			1	15.2	0.2	3.5	1.4	0.0	79.7	..	−.032	Fired 9:15 A.M.
		9:18 A.M.	2	15.8	2.3	0.2	0.0	0.0	81.7	..	+.036	
6	65	to	3	15.2	2.2	0.0	0.0	0.0	82.6	..	−.060	
		9:30 A.M.	4	16.3	1.6	0.0	0.0	0.0	82.1	..	−.072	
			Stack	14.3	3.5	0.2	0.0	0.0	82.0	1065	−.360	Stack analysis 9:15–9:45

TABLE II

RESULTS OF INVESTIGATION (*continued*), RECTANGULAR KILN, SECOND BURN

Set no.	Hour of burn	Time of sample	Position of sample	Composition of gas						Temp., °F	Pressure in water	Furnace gas temp.		Remarks
				CO_2	O_2	CO	H_2	CH_4	N_2			Time	°F	
			1	10.4	8.0	0.6	0.7	0.0	80.3	..	....	...	..	
		2:15 P.M.	2	9.6	8.4	0.0	0.1	0.0	81.9	..	....	...	..	18 inch fuel bed
1	23	to	4	9.9	8.3	0.2	0.0	0.0	81.6	967	....	...	..	Steel doors on fire boxes
		2:50 P.M.	6	9.4	8.0	0.4	0.0	0.0	82.2	785	....	...	..	Fired 1:30. Broke fires
			Stack	8.2	10.6	0.0	0.0	0.0	81.2	466	−.056	...	..	2:30
			1	13.2	0.6	2.5	2.6	1.0	80.1	..	−.025	...	..	18 inch fuel bed
		9:07 A.M.	2	14.4	0.2	2.1	1.1	0.6	81.6	..	+.025	...	..	Doors on fire boxes
2	42	to	4	14.9	0.7	0.8	0.2	0.2	83.2	1544	+.035	...	..	Fired south side
		9:17 A.M.	6	12.1	4.9	0.3	0.0	0.0	82.7	1312	−.030	...	..	9:00 to 9:05
			Stack	9.6	9.2	0.0	0.0	0.0	81.2	769	−.190	...	..	
			1	9.0	8.5	0.0	0.2	0.0	82.3	..	....	...	..	18 inch fuel bed
		1:38 P.M.	2	10.1	9.0	0.3	0.0	0.0	80.6	..	....	...	..	Doors on
3	46	to	4	13.1	5.0	0.2	0.0	0.0	81.7	..	....	...	..	Fired 1:30 to 1:38
		2:06 P.M.	6	11.7	6.1	0.0	0.0	0.0	82.2	..	....	...	..	
			Stack	..	..	...	...	...	..	..	....	...	..	
			1	2.9	10.8	0.0	0.0	0.0	86.3	..	....	...	..	
		2:09 P.M.	2	5.8	11.4	0.0	0.0	0.0	82.8	..	....	...	..	
4	46	to	4	2.8	9.7	0.0	0.0	0.0	87.5	..	....	...	..	
		2:34 P.M.	6	5.0	9.1	0.2	0.0	0.0	85.7	..	....	...	..	
			1	3.1	14.4	0.0	0.0	0.0	82.5	..	....	...	..	
		2:37 P.M.	2	5.1	13.3	0.2	0.0	0.0	81.4	..	....	...	..	
5	46	to	4	7.9	10.4	0.2	0.0	0.0	81.5	1668	....	...	..	
		2:57 P.M.	6	4.4	10.8	0.2	0.0	0.0	84.6	1470	....	...	..	
			Stack	13.3	4.7	0.2	0.0	0.0	81.8	834	−.190	...	..	Stack gas 1:30 P.M.–2:30 P.M.
			1	9.8	0.2	10.4	8.0	0.4	71.2	..	....	...	..	30 inch fuel bed
		10:05 A.M.	2	13.0	0.2	6.0	2.8	0.3	77.7	..	....	10:14	2274	No doors

TABLE II (*Concluded*)

6	67	to	4	..	..	...	...	...	..	2209	....	10:26	2401	Fired 10:00 A.M. open
		10:33 A.M.	6	..	..	...	...	...	..	2024	....	10:40	2529	slightly
		10:35 A.M.	1	15.0	0.9	1.8	0.8	0.1	81.4	..	....	10:50	2401	
7	67	to	2	15.4	1.8	0.3	0.0	0.0	82.5	..	....	11:00	2388	
		11:00 A.M.	Stack	16.4	0.8	0.8	0.0	0.0	82.0	1226	−.215	11:10	2388	Stack gas 67th hour
		11:00 A.M.	1	12.5	5.6	0.2	0.2	0.1	81.4	..	....	11:20	2327	
8	68	to												
		11:30 A.M.	2	12.0	6.8	0.0	0.0	0.0	81.2	..	....	11:30	2162	
		11:30 A.M.	1	12.1	5.7	0.0	0.0	0.0	82.2	..	....	11:40	2159	
9	68	to	2	9.9	9.0	0.0	0.0	0.0	81.1	..	....	...	..	
		11:45 A.M.	6	..	..	...	...	...	..	1924	....	...	..	
			Stack	16.4	0.9	0.8	0.0	0.0	81.9	1239	−.205	...	..	Stack gas 68th hour
		10:20 A.M.	1	14.8	2.2	2.3	1.0	0.1	79.6	..	....	...	..	30 inch fuel bed
10	103	to	2	16.2	0.5	2.5	0.9	0.0	79.9	..	....	10:20	2388	Fired 10:05 to 10:20
		10:45 A.M.	6	14.3	1.9	1.3	0.7	0.2	81.6	2212	....	10:31	2401	Open 2″ to 3″
			4	..	..	...	...	...	..	2253	....	10:40	2314	
		10:45 A.M.	1	13.4	3.8	0.8	0.0	0.1	81.9	..	....	10:50	2361	
11	103	to	2	15.2	2.4	0.1	0.0	0.0	82.3	..	....	11:00	2401	
		11:10 A.M.	6	13.0	3.5	0.0	0.0	0.0	83.5	..	....	11:10	2327	
			Stack	15.8	2.0	0.2	0.0	0.0	82.0	..	−.235	11:20	2321	Stack gas 103rd hour
		11:10 A.M.	1	10.7	7.5	0.0	0.0	0.0	81.8	..	....	11:30	2334	
12	104	to	2	12.2	6.5	0.0	0.0	0.0	81.3	..	...	11:40	2334	
		11:35 A.M.	4	..	..	...	...	...	..	2250	....	11:50	2360	
			6	12.6	4.9	0.0	0.0	0.0	82.5	2233	....	...	..	
		11:35 A.M.	1	12.8	5.8	0.0	0.0	0.0	81.4	..	....	...	..	
13	104	to	2	10.7	8.1	0.0	0.0	0.0	81.2	..	....	...	..	
		11:50 A.M.	6	12.0	6.2	0.0	0.0	0.0	81.8	..	....	...	..	
			Stack	13.6	5.5	0.0	0.0	0.0	80.9	..	−.230	...	..	Stack gas 104th hour

Round Kiln.—The most significant feature of the composition of the gases in this kiln is the absence of any large amounts of combustible gases. The carbon monoxide content of the gases from above the fire-boxes was greater than 1% but twice.

This absence of combustible in the gases from the fire-boxes was due to: (1) rapid combustion in the fire-box, (2) escape of combustible gases outside the kiln.

The rapid combustion in the fire-box was caused by a large air supply per unit mass of combustible gases arising from the fuel bed. Assuming similar depths of fuel beds and the firing openings completely closed with green coal in the furnaces of the two kilns, the ratio of secondary air supply to combustible would be greater for the round than for the rectangular kiln, because:

1. The size of the coal used on the round kiln was greater and thus the voids for the passage of air through the firing opening were larger.

2. The ratio of the firing opening to the effective grate area, as shown in item 10 of Table I and hence the ratio of secondary air supply to combustible, was much larger for the dead bottom furnace than for the grate bar furnace.

The fresh charges of coal lay in the openings on the hub and it was evident from observation that a large part of the volatile content of the coal did not enter the kiln. Had it entered the kiln there would have been a higher content of combustible gases in the samples from above the fire-boxes, particularly immediately after firing.

The absence of combustible gases in this kiln was, therefore, owing to the fact that the combustion in the furnace was rapid because of a high ratio of secondary air to combustible and to the loss of volatile combustible matter outside the kiln.

The rate of combustion of the gases within the kiln itself was of the same order as in the rectangular kiln.

The readings taken in this kiln show the existence of a pressure greater than atmospheric near the top of the kiln.

Conclusions

This investigation showed that combustion of the gases arising from the fuel bed took place very rapidly in both types of kilns. The incandescent checker work of the setting furnished the previously noted requirements for rapid combustion of the gases, namely, thorough mixing, and high combustion chamber temperature. The hot surface of the ware also undoubtedly acted as a catalyst for the reactions.

In samples taken over a short period combustible gases occurred only in the absence of oxygen. Combustion of the gases took place almost immediately upon admission of secondary air to the gas stream and delayed

combustion could, therefore, only be secured by delaying the admission of the secondary air. As there was a pressure greater than that of the air at the same level at all points in the upper part of the kilns, secondary air could be introduced here only by means of a forced draft system. The air could be introduced into the bottom and center of the kiln by natural draft through air ducts to the desired points.

Another method, applicable to the rectangular kiln, would be that of firing alternate ends of the kiln, one tightly closed to secure a large supply of combustible gases and the other open to provide an excess of air. The combustion of the gases would take place when the two gas streams met and thus the heat of the gases would be released closer to the ware at the center and bottom of the kiln. An obvious difficulty of this method, when the firing openings are closed by coal, would be to maintain the deficiency in air supply over a considerable period of time. If the coal burned down to admit enough air for complete combustion the gas temperature would rise very high and the ware near the fire-boxes would be over-burned.

This method has been tried on later burns at this plant. On the first trial the ends were over-burned but a higher temperature was secured in the bottom. By further work with the method they have reduced the coal consumption and have reduced the temperature difference between ends and center by more than 2 cones.

This method does not lend itself so well to the round kiln owing to the more uniform distribution of the fire-boxes around the periphery.

Although the gaseous combustion takes place so rapidly, the combustion of the carbon particles, as has been pointed out, is very slow and extends throughout the kiln and possibly through the flues and stack. These incandescent particles of soot, together with ash, are the flames observed in the setting and often at the top of the stack. The heat liberated by the combustion of the soot within the setting is probably inconsiderable compared to that which would result from the combustion of gases.

The incandescent particles, however, perform an important function in the distribution of the heat in the kiln. They are heated to incandescence by the heat of combustion at the fuel bed and carry this heat within the setting to deliver it to the ware by radiation. If this flame were absent, the ware in the interior of the setting would receive heat only by convection and by conduction from the hotter outer ware which is also receiving heat by radiation from the fuel beds. The transmission of heat by radiation varies as the fourth power of the absolute temperature, whereas transmission by convection and conduction varies as the first power of the temperature difference.

This is the value of the "long flame" coals and "long flame" conditions in a brick kiln or in any process requiring a uniform temperature

where a large mass of the material to be heated is out of "sight" of the fuel bed.

To again sum up the results, it was found in the two types of refractory kilns investigated that:

1. Combustion of the gases from the fuel bed was complete within a short distance from the point of secondary air admission.

2. Combustion of the gases can be carried to the center and bottom of the kiln only by the admission of secondary air at the desired point. This may be done by means of forced draft or air ducts according to whether the pressure at the point is above or below that of the atmosphere, or by a method of alternate firing in the rectangular type of kiln.

3. The attainment of a uniform temperature throughout the kiln is, in general, a problem of the uniform distribution of the hot gases rather than one of gaseous combustion.

NOTE: Grateful acknowledgment is made of the assistance and suggestions of John Blizard, Fuel Engineer, and G. A. Bole, Superintendent of the Columbus Station of the Bureau of Mines, at whose suggestion and under whose direction the work was undertaken, of the valuable assistance of the members of the crew of the car "Holmes," and of the kind coöperation of the superintendents and workmen at the plants where the work was done.

STRENGTH, ABSORPTION AND FREEZING RESISTANCE OF HOLLOW BUILDING TILE[1]

By H. D. Foster

ABSTRACT

This paper describes the test methods and gives a summary of the compressive strength and absorption determinations of nearly 350 tests of tile selected from twenty-five representative sources. A preliminary report of the resistance to freezing and thawing of tile from seventeen representative sources is also given. The following conclusions were made: (*a*) The weight of tile per unit of solid material varies from 20 to 30%. (*b*) The weight per unit volume of material is closely related to the absorption and decreases as the absorption increases. (*c*) The strength of tile varies with the type of raw material used. (*d*) The unit strength based on gross area of an end construction tile tested on edge is 38% of that obtained when tested on end. (*e*) The relation between strength and absorption is not linear but a plotted curve shows increasing gain in strength with a decrease in absorption. (*f*) Color cannot be taken as indicative of strength. (*g*) The modulus of elasticity varies from 1,600,000 to 6,060,000 and is approximately directly proportional to the strength and inversely proportional to the absorption. (*h*) An absorption of 16% apparently marks a very definite line in the resistance of tile to freezing and thawing.

1. Introduction

Only a little information showing the physical properties of the various grades of hollow building tile has been made available and is insufficient for the intelligent formation of standard specifications and building code requirements. The industry, aware of this condition, has during the past few years coöperated with the Bureau of Standards in conducting a considerable amount of research work on its product primarily to obtain information on hollow tile as a fire retardant. Along with the fire tests, auxiliary tests are being made on representative tile to determine compressive strength, absorption and resistance to freezing, on the results of which this paper is a preliminary report. Papers dealing with the methods of procedure in making compressive strength and absorption determinations have been previously given before this Society.[2]

2. Scope of Tests

Hollow building tile is manufactured from a wide range of clay materials. These fall into the following general classes: (*a*) shales, (*b*) dense burning fire clays, (*c*) open burning fire clays, (*d*) surface clays.

Approximately 350 tiles from 25 representative sources, including 7 shales, 5 dense burning fire clays, 4 open burning fire clays, and 9 surface clays

[1] Recd. Jan. 11, 1924. Presented at the Atlantic City Meeting, February, 1924. (Heavy Clay Products Division.)

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[2] H. D. Foster, "Capping for Compression Specimens," *Jour. Amer. Ceram. Soc.*, **6** [5], 623–9 (1923); "Effectiveness of Different Methods of Making Absorption Determinations," *Ibid.*, **5** [11], 788–97 (1922).

were tested in compression. Most of the compression tests were made with the tile in the position in which they are normally used. Some of the end construction tile were also tested on edge, a position in which they are sometimes used. The absorption of all tile broken in compression was determined. Stress-strain readings for the modulus of elasticity determinations were taken on 80 tile from 18 representative sources. Freezing tests are being made on pieces of 54 tile taken from 18 representative sources.

The sizes of the tile tested were those most commonly used in load-bearing construction, namely, 8 x 12 x 12 inches, 4 x 12 x 12 inches, 8 x 5 x 12 inches, Denison "H" and Interlocking. Information on the effect of size on strength can be obtained from a previous publication wherein the strengths of various sizes of tile, mostly of a fire clay origin, are given.[1]

3. General Test Procedure

(*a*) **Selecting, Weighing and Measuring Test Samples.**—Five or more tile representative of the variations in quality obtaining at each plant were selected for the tests. The dry weights of these tile were then determined. As the net horizontal sectional area of each tile when laid in the position in which it is to be tested is necessary as a basis for the computation of the increments of loading and the unit load, the exact size of the tile and the thickness of the shells and the webs were measured with calipers. From these measurements the net and gross sectional area and the volume of solid material in the unit were computed.

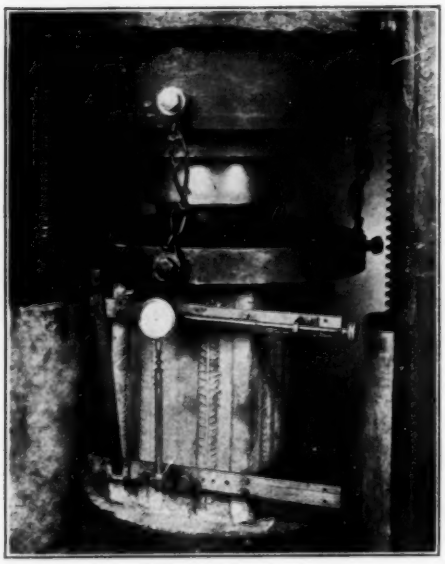

FIG. 1.

(*b*) **Details of Compression Tests.**—Previous to testing, the tile were capped to insure uniform bearing in the testing machine. After coating the bearing surfaces and adjacent parts with shellac to keep the tile from absorbing water from the plastic cap, they were capped with a mixture of one part of plaster of Paris and three parts of cement in the following manner: A quantity of the capping material mixed with enough water

[1] Bureau of Standards, *Tech. Paper* **120**, "Tests of Hollow Building Tiles."

to give it a consistency such that it could be spread evenly on a glass plate which had been moderately coated with oil. One bearing surface of the tile was then set in this plastic material and while holding the tile so that with axis vertical it was fixed in position by the application of a single firm pressure. As soon as the cap had hardened sufficiently the tile was removed from the plate and the other end capped in the same manner. The caps were from $^1/_{16}$ to $^1/_8$ inch thick. No caps were patched, imperfect ones being removed and replaced with new ones. The caps were allowed to age from 5 to 7 days before the tile were tested.

In testing, each tile was placed on the weighing table of the machine (Fig. 1) in such manner that its vertical axis coincided with a vertical line passing through the center of the movable head and through the center of the hemispherical bearing block. As the movable head was lowered the lower part of the bearing block was allowed to seat itself on the top bearing surface of the tile and the top part of the bearing block was slowly rotated as it came in contact with the movable head in order to secure even bearing. By carefully placing the tile in this manner no difficulty was experienced in consistently obtaining good breaks many of which showed very definitely the typical compression cone.

The tests were made in a 300,000-pound Riehlé testing machine, the actual breaking speed of the moving head being slightly less than 0.05 inch per minute. The load was applied continuously, readings of the compressometer being taken at loading increments of 500 pounds per square inch of net sectional area. The compressometer used (Fig. 1) consists essentially of a bottom yoke which is attached rigidly to the tile, a top yoke which is pivoted by two screws placed on the sides and opposite the vertical axis of the test specimen. The rear of this yoke is held a fixed distance from the bottom yoke. The front of this yoke is free to move downward with the deformation of the center of the tile, the movement with respect to the bottom yoke being measured with a dial gage. This measurement when multiplied by an instrument constant gives the average deformation of the test specimen.

Strain readings were taken in tests when the tile was tested with its cells vertical. The initial strain reading was not taken until a load of 100 pounds per square inch of net sectional area had been applied. Further readings were taken at loading increments of 500 pounds per square inch until failure was approached.

(*c*) **Details of Absorption Tests.**—Three pieces for absorption determinations were selected from each tile broken in compression. Two of the three pieces were taken from opposite shells and one from the center web. The pieces selected were free from cracks from the failure of the tile in compression and were of such size as to weigh not less than 225 grams or 8 ounces.

After the loose edges and rough particles were ground off, the pieces were dried to constant weight. They were then immersed in water and saturated by boiling for four hours and cooling to room temperature. After saturation the pieces were removed from the water and allowed to drain for not more than one minute. The superficial water was then removed with a damp cloth after which the pieces were weighed immediately.

The weight of the water absorbed multiplied by 100 and divided by the dry weight of the pieces gave the percentage absorption. While the absorption results in this paper are based on 4-hour boiling it was found in a separate investigation[1] that only a small difference obtains with one-hour and four-hour boiling as applied to clay hollow tile.

(*d*) **Details of Freezing Tests.**—Three tiles, one hard-fired, one medium-fired and one soft-fired were selected from each of seventeen kinds of tile for the freezing tests. In order to avoid the presence of cracks in the specimens for freezing tests they were sawed from whole tile by means of a large stone saw. The absorption of these specimens was obtained as described above. The specimens were then placed in the freezing machine wherein they were alternately cooled and held for a few hours at a temperature below —10°C and thawed by a flow of tap water. Frequent inspections and weighings of the test specimens were made in order to determine the loss. Before each weighing all loosened pieces liable to be knocked off in ordinary usage were removed. Photographs showing the condition of the test specimens were made at intervals determined by the loss incurred.

4. Results and Discussion of Tests

(*a*) **Weight.**—The weight per unit volume of burned material in the tile tested, as shown in Table I, was found to vary from 0.060 to 0.082 pound per cubic inch, averaging 0.071 pound (from 103 to 141 pounds per cubic foot, averaging 123 pounds). These variations probably represent the range that can be expected as the tile tested were representative of the entire product of the industry. They do not, however, include the very porous material which has been made by the addition of large amounts of sawdust, this tile not being used for load bearing construction. The variations in weight depend upon the specific gravity of the clay as influenced by its mineral constituents and upon differences in porosity caused by differences in the fineness of grinding of the raw material, by non-uniformity in mixing the materials, by differences in pressure to which the clay is subjected while being molded and by differences in burning temperatures. As the variation in specific gravity is small, a

[1] "Effectiveness of Different Methods of Making Absorption Determinations," *loc. cit.*

fairly definite relation should be found between the absorption and the unit weight. This relation is shown graphically in Fig. 2. It is suggestive of a short way of approximating the absorption of tile.

(*b*) **Compression and Absorption Tests.**—A summary of the results of the compression and absorption tests, including the size and type of tile, the position in which tested, the sectional area, the maximum load sustained, the range and average unit load, the range and average percentage absorption and the modulus of elasticity, are given in Table I. The results are arranged in order of the strengths of the tile as based on their net sectional area. This gives them a rank in strengths as follows: shales, dense burning fire clays, open burning fire clays, and surface clays. From this table it can be seen that all of the shale and dense burning fire clay tiles that were tested could be classed as hard, that the open burning fire clay tiles and some surface clay tiles would be classed as medium, and that many surface clay tiles would be classed as soft. These statements do not hold, however, unless the tile is well burned.

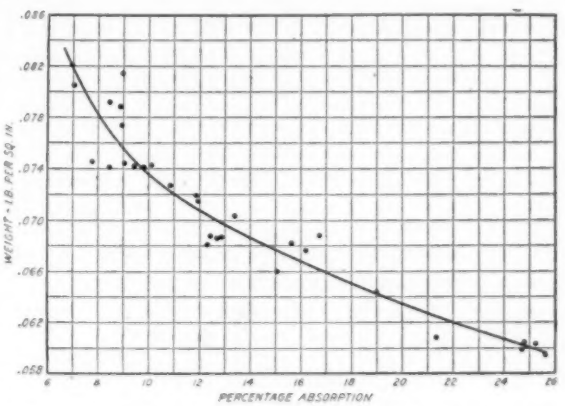

FIG. 2.—Relation between unit weight of constituent material in tile and absorption.

It is evident that there is a relation, as shown in Fig. 3, between absorption and strength, but this relation cannot be definitely fixed as applying to tile in general. A more definite relation can be derived and made to apply to the product from a given source of material.

It was found in general that the modulus of elasticity of the tile was nearly constant until failure. This is especially true with the denser burned tiles, as failure always occurred suddenly, while with the more porous tiles the modulus of elasticity gradually decreased as the maximum load was approached. In general it was found that the higher the modulus the higher the compressive strength. The modulus of elasticity varies inversely with the absorption as shown in Fig. 4. A similar but direct relation exists between the modulus of elasticity and the strength.

All kinds of end construction tile were also tested on edge, the strength of the tile when tested on edge being given in the table immediately following the strength of that same kind of tile when tested on end. It is shown that the strength of the tile when tested on edge is from 33 to 99%

as strong, based on net sectional area, as when tested on end. However, as the area in compression when the tile is laid on edge is on the average only 60% of that when it is laid on end, the actual strength of the unit on edge is approximately 20 to 60% of the strength on end. This difference can be attributed to the design of the tile and to the orientation of the lamination planes and clay particles during the flow of the plastic clay material through the die. In end construction tile these planes are always parallel to the direction of application of the load and have little effect on the strength, while with side construction tile they are always perpendicular to the direction of application of the load and appreciably affect the strength. This is evidenced by the Kentucky shale which has no laminations and which loses very little strength on the net sectional area when turned on edge, and by the New Jersey surface clay where laminations are present and which loses a large amount of strength when turned on edge. It must be appreciated, however, that this conclusion is not based on the results of tests of tiles designed for side construction whose efficiency in the masonry wall is probably greater than that of end construction laid on edge.

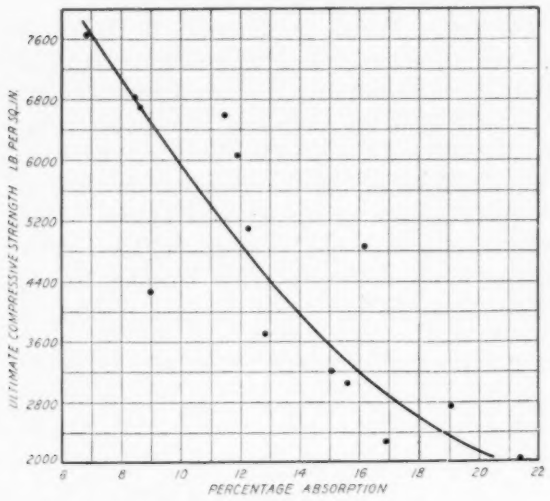

FIG. 3.—Relation between strength and absorption.

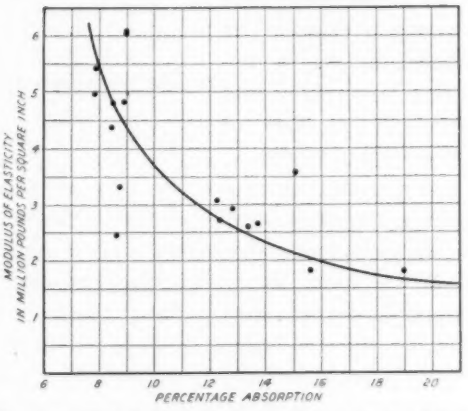

FIG. 4.—Relation between modulus of elasticity and absorption.

Attention should be called to the fact that there is no relation between strength and color or between absorption and color that can be used for all tile because of the various kinds of clay used in the industry.

There may be, however, a fairly definite relation that can be applied to the products from each source.

No definite relation between the weight of the tile unit and the strength can be derived from these tests, although the trend of results indicates a general increase of gross area strength with increase in weight. Although tile of varying weights were tested, they were from different sources wherein the variation in clay was so great that this relation was more or less concealed. With one exception, all tile from each source were in general of the same weight. In the one case two lots of tile were submitted. In the second lot the weight of the unit was increased 18.4% and the strength was increased 41.3%. A part of this increase in strength was due to a 2.4% reduction in absorption.

FIG. 5.—Condition of shale tile after 100 alternate freezings and thawings.

(*c*) **Freezing Tests.**—The work on freezing, though not complete,

TABLE II

RESULTS OF FREEZING TESTS

Laboratory identification	Kind of clay	Percentage absorption	Percentage loss after 90 freezings
A	Shale	10.5	1.6
B	Shale	5.5	0.0
C	Shale	7.3	0.0
D	Shale	9.9	0.1
E	Shale	12.6	0.2
S	Shale	6.9	0.1
F	Fire clay	9.3	0.0
H	Fire clay	12.0	1.3
L	Fire clay	6.8	0.0
M	Fire clay	6.5	0.0
N	Fire clay	8.7	0.0
P	Fire clay	8.8	0.0
J	Surface clay	22.1	3.7
K	Surface clay	13.3	0.1
O	Surface clay	21.8	13.1
Q	Surface clay	6.4	0.4
R	Surface clay	10.3	0.2

SUMMARY OF RESULTS OF COM

Laboratory identification	Kind of clay	Source	No. of tests	Nominal size, inches	No. of cells	Position in which tested	Area under compression, sq. in. Gross	Net	No volu cu.
A	Shale	Indiana	4	8x12x12	4	End	96.10	30.04	378
	Shale	Indiana	3	8x12x12	4	Edge	96.50	17.93	..
G	50% fire clay 50% shale	Alabama	5	8x12x12	4	End	98.44	36.65	426
	50% fire clay 50% shale	Alabama	4	8x12x12	4	Edge	93.99	20.47	..
F	Fire clay containing 15% shale	Ohio	5	8x12x12	4	End	100.55	34.44	414
	Fire clay containing 15% shale	Ohio	3	8x12x12	4	Edge	99.90	21.45	..
O	High lime surface clay	Illinois	5	8x12x12	4	End	94.80	39.70	479
	High lime surface clay	Illinois	5	8x12x12	4	Edge	96.33	26.15	..
C	Shale	Iowa	3	8x12x12	6	End	93.40	29.63	350
	Shale	Iowa	3	8x12x12	6	Edge	95.62	18.99	..
D	Shale	Kentucky	5	8x12x12	6	End	91.92	38.16	448
	Shale	Kentucky	5	8x12x12	6	Edge	93.29	21.77	..
	Shale	Kentucky	5	8x12x12	6	End	93.06	38.15	446
L	Dense burning fire clay	Ohio	5	8x12x12	6	End	98.31	40.99	482
	Dense burning fire clay	Ohio	5	8x12x12	6	Edge	96.35	22.00	493
	Dense burning fire clay	Ohio	5	8x12x12	6	End	96.33	42.26	..
	Dense burning fire clay	Ohio	5	8x12x12	6	Edge	96.02	21.43	..
M	Dense burning fire clay	Ohio	5	8x12x12	6	End	99.11	39.74	..
	Dense burning fire clay	Ohio	5	8x12x12	6	Edge	97.43	18.55	..
N	Open burning fire clay	New Jersey	5	8x12x12	6	End	91.76	38.26	452
	Open burning fire clay	New Jersey	5	8x12x12	6	Edge	91.42	19.59	..
P	Open burning fire clay	New Jersey	5	8x12x12	6	End	92.85	42.01	509
	Open burning fire clay	New Jersey	5	8x12x12	6	Edge	94.18	21.76	..
H	Open burning fire clay	Texas	5	8x12x12	6	End	90.42	41.84	495
	Open burning fire clay	Texas	3	8x12x12	6	Edge	92.99	26.29	..
K	Surface clay	New Jersey	5	8x12x12	6	End	91.88	43.50	515
	Surface clay	New Jersey	3	8x12x12	6	Edge	91.64	27.16	..
Y	Surface clay	New Jersey	5	8x12x12	6	End	100.93	41.58	499
	Surface clay	New Jersey	5	8x12x12	6	Edge	98.04	19.90	501
Q	Surface clay	Massachusetts	5	8x12x12	6	End	92.91	37.45	447
	Surface clay	Massachusetts	4	8x12x12	6	Edge	99.89	21.65	..
J	Surface clay	New York	5	8x12x12	6	End	98.28	52.53	536
	Surface clay	New York	5	8x12x12	6	Edge	100.40	32.38	..
	Surface clay	New York	5	8x12x12	9	End	89.37	46.59	566
D	Shale	Kentucky	5	4x12x12	3	End	45.48	21.24	246
	Shale	Kentucky	5	4x12x12	3	Edge	46.19	13.24	254
L	Dense burning fire clay	Ohio	5	4x12x12	3	End	46.73	20.80	245
	Dense burning fire clay	Ohio	5	4x12x12	3	Edge	46.64	12.15	244
J	High lime surface clay	New York	5	4x12x12	3	End	47.80	23.01	282
	High lime surface clay	New York	5	4x12x12	3	Edge	48.47	14.97	..
	High lime surface clay	New York	5	4x12x12	3	End	47.65	25.25	308
	High lime surface clay	New York	5	4x12x12	3	Edge	48.70	17.69	..
B	Shale	Iowa	3	8x5x12	3	Side	94.32	21.18	..
C	Shale	Iowa	5	8x5x12	3	Side	99.51	26.34	..
D	Shale	Kentucky	5	8x5x12	2	Side	93.95	22.16	195
E	Shale	Kansas	5	8x5x12	2	Side	98.21	23.04	215
L	Dense burning fire clay	Ohio	2	8x5x12	2	Side	97.12	22.36	198
M	Dense burning fire clay	Ohio	3	8x5x12	2	Side	98.30	21.48	..
R	50% shale 50% surface clay	Ohio	5	8x5x12	2	Side	94.07	20.32	184
HO	Surface clay	Indiana	11	8x5x12	3	Side	97.30	32.33	..
ST	Surface clay	Georgia	12	8x5x12	3	Side	95.13	26.75	..
BA	Dense burning fire clay	Ohio	25	8x5x12	2	Side	92.87	22.61	..
MC	Shale	Iowa	5	Denison H No. 47	...	Side	95.73	27.44	446
L	Dense burning fire clay	Ohio	10	Denison H No. 47	...	Side	95.85	27.07	..
PB	Shale	Kentucky	10	Interlocking	...	Side	93.28	23.31	..
CP	Fire clay	Indiana	10	Interlocking	...	Side	98.73	26.06	..
FR	Open burning fire clay	Texas	8	Interlocking	...	Side	95.55	35.24	..
FR	Surface clay	Texas	10	Interlocking	...	Side	98.72	29.62	..
Y	Surface clay	New Jersey	10	Interlocking	...	Side	95.08	23.91	...
	Surface clay	New Jersey	10	Interlocking	...	Side	90.95	22.34	..

TABLE I

LTS OF COMPRESSION AND ABSORPTION TESTS

ler ion, Net	Net volume, cu. in.	Weight Total	Weight Per cu. in.	Maximum load, pounds	Unit strength Lbs./sq. in. of gross area Range	Lbs./sq. in. of gross area Average	Lbs./sq. in. of net area Range	Lbs./sq. in. of net area Average	Absorption, per cent Range	Absorption, per cent Average	Modulus of elasticity in million pounds per. sq. in.
30.04	375.84	27.76	.0741	144330	1177 to 1804	1509	3591 to 5768	4838	6.6 to 12.4	8.44	4.354
17.93	....	...	...	47300	393 to 557	490	2085 to 3032	2643	6.0 to 12.3	7.52	.....
36.65	424.51	32.71	.0744	157793	1204 to 2203	1606	3177 to 6070	4327	6.9 to 11.1	8:91	4.814
20.47	....	...	...	91649	866 to 1155	975	3896 to 5427	4483	8.6 to 9.8	9.36	.....
34.44	414.14	28.41	.0688	152906	1082 to 1968	1520	3000 to 5918	4454	10.9 to 13.7	12.39	2.731
21.45	....	...	...	31392	289 to 360	314	1278 to 1700	1468	12.1 to 13.5	12.48	.....
29.70	479.83	28.93	.0605	91606	680 to 1293	978	1597 to 3081	2304	22.7 to 25.8	24.85	1.620
26.15	....	28.89	...	40681	308 to 687	424	1155 to 2476	1554	22.7 to 25.6	24.07	.....
29.63	350.78	28.54	.0814	127087	1275 to 1476	1362	4043 to 4570	4288	7.7 to 11.0	8.99	6.059
18.99	....	...	...	34580	326 to 397	361	1612 to 2034	1825	8.1 to 12.5	9.71	.....
38.16	448.04	35.49	.0792	260191	1971 to 3453	2826	4697 to 8230	6821	6.4 to 10.9	8.47	4.826
21.77	....	...	...	145011	1260 to 1932	1557	5431 to 8224	6667	7.1 to 10.6	8.56	.....
38.15	446.05	36.61	.0821	293057	2726 to 3520	3150	6737 to 8614	7683	5.8 to 7.5	6.89	.....
40.99	482.69	34.70	.0715	250325	1592 to 3008	2546	3834 to 7127	6118	10.8 to 15.0	11.92	.....
42.00	493.61	35.52	.0719	95155	852 to 1092	989	3777 to 4808	4325	10.6 to 12.5	11.89	.....
42.26	....	35.26	...	278836	2610 to 3114	2897	5949 to 7099	6598	10.5 to 12.4	11.47	.....
21.43	....	35.14	...	93976	848 to 1157	978	3797 to 5185	4385	9.6 to 14.0	11.69	.....
39.74	....	...	...	265868	2451 to 2975	2681	6113 to 7418	6691	7.6 to 11.0	8.65	2.426
18.55	....	32.30	...	75619	599 to 996	776	3145 to 5230	4076	5.7 to 10.4	8.12	.....
38.26	452.30	30.77	.0681	206040	1783 to 2723	2250	4438 to 6565	5103	8.7 to 14.5	12.29	3.080
9.59	....	30.95	...	53186	461 to 680	581	2075 to 3298	2722	8.7 to 13.0	11.14	.....
42.01	509.27	34.98	.0687	155160	1228 to 2017	1675	2713 to 4461	3704	11.0 to 15.7	12.85	2.920
41.76	....	35.86	...	51251	470 to 611	544	1981 to 2625	2359	12.2 to 15.6	13.62	.....
41.84	495.99	33.81	.0682	127094	1091 to 1568	1408	2350 to 3334	3042	14.5 to 17.2	15.61	1.818
36.29	....	...	...	31330	312 to 368	336	1086 to 1313	1192	15.2 to 17.0	15.81	.....
43.50	515.74	33.60	.0660	138771	1369 to 2036	1508	3033 to 4342	3213	7.8 to 19.2	15.07	3.595
37.16	....	...	...	32516	275 to 441	355	966 to 1439	1193	11.4 to 17.4	13.57	.....
41.58	499.72	33.85	.0677	202777	1806 to 2237	1900	4367 to 5360	4872	15.0 to 17.6	16.20	.....
39.90	501.83	33.82	.0668	50476	386 to 644	516	1983 to 3286	2538	16.1 to 17.3	16.74	.....
37.45	447.67	32.40	.0741	237729	1894 to 3871	2639	4487 to 11075	6644	2.4 to 15.3	9.79	4.418
41.65	....	33.74	...	49329	407 to 543	493	1806 to 2686	2296	16.0 to 17.7	16.88	.....
42.53	536.02	40.86	.0644	144504	1296 to 1667	1473	2347 to 3176	2761	16.2 to 20.8	19.02	1.825
42.38	....	41.10	...	71481	525 to 889	710	1523 to 2974	2253	14.7 to 23.1	19.43	.....
36.59	566.99	34.51	.0609	93863	584 to 1437	1050	1104 to 2743	2019	16.8 to 24.4	21.39	.....
31.24	246.25	19.83	.0805	241181	4719 to 5645	5304	10175 to 12195	11349	6.4 to 7.5	7.02	.....
33.24	254.43	20.08	.0789	121343	2237 to 3068	2630	7858 to 10578	9216	7.2 to 9.6	8.87	.....
30.80	245.88	18.23	.0742	189786	3311 to 4572	4060	7452 to 10610	9197	8.2 to 11.0	9.42	.....
32.15	244.05	18.14	.0744	86713	1527 to 2296	1861	6032 to 8812	7141	7.6 to 10.3	9.01	.....
33.01	282.53	16.79	.0595	61595	940 to 1515	1291	1922 to 3227	2689	25.0 to 26.5	25.64	.....
34.97	....	16.69	...	28876	512 to 744	596	1631 to 2394	1932	24.8 to 27.0	26.11	.....
35.25	308.47	18.46	.0599	78584	1106 to 1989	1654	2323 to 3720	3102	23.6 to 25.4	24.77	.....
37.69	....	18.54	...	39311	493 to 1241	807	1354 to 3500	2229	23.4 to 25.5	24.53	.....
31.18	....	15.04	...	67987	687 to 751	721	2920 to 3489	3227	1.4 to 18.1	11.92	4.994
36.34	....	16.03	...	90902	839 to 1020	914	3175 to 3943	3457	9.0 to 14.4	10.50	6.059
32.16	195.79	14.54	.0743	117140	1292 to 1617	1376	5348 to 6680	5730	8.6 to 10.9	10.09	.....
33.04	215.13	15.29	.0703	67747	572 to 877	690	2388 to 4048	2967	11.1 to 14.8	13.39	2.657
32.36	198.88	14.84	.0746	132710	1028 to 1702	1365	4608 to 7165	5886	6.4 to 8.6	7.77	5.443
31.48	....	16.09	...	71658	607 to 950	781	2831 to 4266	3336	6.8 to 10.3	8.74	3.325
30.32	184.65	13.42	.0727	119712	1154 to 1451	1273	5368 to 6705	5885	10.2 to 12.0	10.83	.....
32.33	....	15.05	...	75065	600 to 1055	767	1798 to 3083	2309	24.1 to 26.1	25.11	.....
36.75	....	14.79	...	90691	730 to 1482	1000	2438 to 5042	3372	12.8 to 16.8	14.40	.....
32.61	....	14.92	...	109499	864 to 1622	1182	3574 to 6635	4855	6.9 to 16.3	11.55	.....
37.44	446.86	30.67	.0686	61413	408 to 862	644	1432 to 2985	2239	10.5 to 15.4	12.66	.....
37.07	....	32.55	...	137868	989 to 1741	1439	3539 to 6273	5113	8.9 to 12.4	10.54	.....
33.31	....	15.12	...	114984	839 to 1527	1259	3237 to 6203	4954	6.8 to 15.3	11.38	.....
36.06	....	17.81	...	114791	864 to 1580	1156	3384 to 5680	4407	4.1 to 10.2	6.41	.....
35.24	....	17.75	...	136100	1278 to 1638	1425	3505 to 4296	3861	9.0 to 13.1	10.62	.....
29.62	....	18.31	...	93116	835 to 1134	942	2770 to 3742	3141	9.7 to 15.3	12.95	.....
33.91	....	14.74	...	53253	446 to 672	559	1668 to 2692	2231	11.6 to 15.3	13.45	.....
32.34	....	14.67	...	62774	535 to 928	691	2108 to 3801	2819	7.4 to 9.7	8.62	.....

TABLE III

CHEMICAL ANALYSIS OF HOLLOW BUILDING TILE CLAYS

Laboratory identification	Kind of clay	Source	SiO_2	Total iron as Fe_2O_3	Al_2O_3	Mn_2O_4	P_2O_5	CaO	MgO	Na_2O	K_2O	SO_3	CO_2	Loss on ignition[1]	Total flux
A	Shale	Indiana	50.90	10.20	18.53	0.15	1.80	2.23	2.07	0.41	3.03	0.18	4.30	9.98	19.89
B	Shale	Iowa	48.92	4.30	17.97	trace	0.09	6.27	4.09	0.09	4.10	0.93	8.71	12.68	18.94
C	Shale	Iowa	31.74	9.90	1.91	0.09	0.26	17.22	10.19	0.27	1.18	0.20	23.90	26.52	39.11
D	Shale	Kentucky	57.68	8.10	18.00	0.06	1.54	1.01	2.21	0.83	4.07	0.65	1.04	6.16	17.82
E	Shale	Kansas	55.66	6.00	16.40	trace	1.36	0.46	3.53	0.93	2.59	0.23	0.29	12.34	14.87
F	Fire clay	Ohio	57.68	1.70	27.53	trace	0.13	0.31	0.80	0.33	1.67	1.10	4.28	9.58	4.94
G	Shale	Alabama	62.12	5.40	19.95	trace	1.27	0.18	1.34	0.47	2.97	0.24	0.00	6.38	11.63
H	Fire clay	Texas	63.20	0.20	26.43	0.07	trace	0.20	0.36	0.13	0.30	0.34	0.03	9.14	1.26
J	Surface clay	New York	57.66	5.75	16.04	0.04	0.29	6.46	2.79	1.35	2.87	1.15	0.85	5.16	19.55
K	Surface clay	New Jersey	57.45	7.25	19.36	trace	0.14	0.30	1.12	0.60	1.57	3.68	0.50	11.15	10.98
L	Fire clay	Ohio	55.32	4.20	24.97	trace	0.33	0.39	0.75	0.59	2.08	3.41	0.39	10.46	8.34
M	Fire clay	Ohio	61.40	1.50	26.60	trace	trace	0.55	0.37	0.60	0.90	1.13	0.00	8.05	3.92
N	Fire clay	New York	67.70	3.55	18.48	trace	0.37	0.20	0.52	0.50	1.75	1.15	0.20	6.65	6.89
O	Surface clay	Illinois	49.74	0.70	17.55	0.05	0.34	8.48	4.85	0.65	3.38	0.39	9.55	13.88	18.45
P	Fire clay	New Jersey	61.45	2.15	22.80	trace	trace	0.35	0.30	0.34	2.14	2.24	0.02	9.35	5.28
Q	Surface clay	Mass.	57.65	5.05	21.83	0.09	0.48	1.45	2.59	2.12	3.88	0.15	0.05	4.03	15.66

Organic material detected in all samples, appreciable amounts being present in samples F, G, H, J, K, L, M, N and P.

[1] This figure represents total loss on ignition at the temperature of the blast and is the algebraic sum of various changes including loss of CO_2. (See W. F. Hillebrand, U. S. Geol. Surv., *Bull.* **700,** 231, and J. W. Mellor, "Treatise on Quantitative Inorganic Analysis," pages 157–159.) The results for samples K, L, M, N and P are apparently too high, probably owing to the reduction of sulphate to sulphide by the organic matter present.

has been carried far enough to indicate what tiles are liable to fail when subjected to freezing conditions. The detailed results of the first 90 alternate freezings and thawings are shown in Table II. The condition of the specimens after 100 freezings is shown in Figs. 5, 6 and 7. It will be noted from this table and the figures that the tile having an absorption over 16% were not able to withstand 100 alternate freezings and thawings without decided effects. The tile having the highest absorption suffered the greatest loss in freezing. From the photographs it can also be seen that tile with laminations are more likely to show effects in the freezing tests than tile of uniform structure.

FIG. 6.—Condition of fire clay tile after 100 alternate freezings and thawings.

(*d*) **Miscellaneous Determinations.**—The chemical composition and the fusion point of the clays have been determined and are given in Tables III and IV. These determinations were made so their relation to fire resistance might be studied. No attempt has been made to derive their relation to the strength, absorption and freezing resistance, but they are given here as an aid in defining the clay materials from which the tile tested were made.

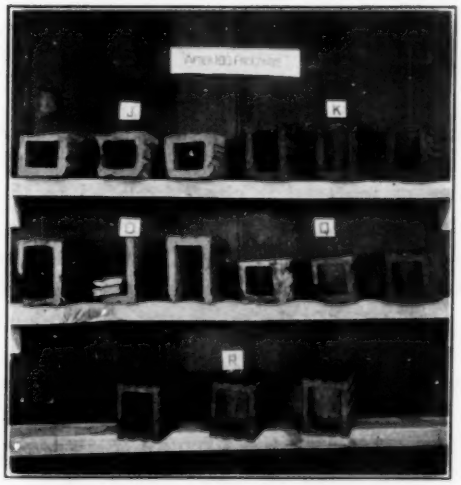

FIG. 7.—Condition of surface clay tile after 100 alternate freezings and thawings.

5. Conclusions

The following conclusions, drawn from the tests collated in this paper, are based directly on the results obtained, and have a fairly wide application owing to the range in tile tested. In drawing independent con-

clusions, however, it must be remembered that there are great variations because of the many classes and grades of clay used in hollow tile manufacture, and those results obtained from tile made from the same grade and type of clay in question should be used.

TABLE IV

FUSION POINTS OF HOLLOW BUILDING TILE CLAYS

Laboratory identification	Kind of clay	Source	Fusion point, degrees Centigrade
A	Shale	Indiana	1100
B	Shale	Iowa	1140
C	Shale	Iowa	1145
D	Shale	Kentucky	1180
E	Shale	Kansas	1240
F	Fire clay	Ohio	1390
G	Shale	Alabama	1325
H	Fire clay	Texas	? (Cone 19)
J	Surface clay	New York	1170
K	Surface clay	New Jersey	1335
L	Fire clay	Ohio	1350
M	Fire clay	Ohio	? (Cone 20)
N	Fire clay	New York	1390
O	Surface clay	Illinois	1130
P	Fire clay	New Jersey	? (Cone 19)
Q	Surface clay	Massachusetts	1330

In obtaining these fusion points the furnace was heated to 1000°C in one hour. After the first hour the temperature was increased at the rate of 50°C per hour until the fusion point was reached. A platinum, platinum-rhodium thermocouple was used, the end of which was placed not more than three-eighths inch from the tip of the test cone. Each determination was checked two or more times. The fusion points of three clays, H, M, and P, were not accurately determined but were compared with Orton pyrometric cones.

1. The weight of tile per unit volume of solid material varies from 20 to 30% with the change in specific gravity of the clay and the details of manufacture.

2. The weight per unit volume of material is closely related to the absorption and decreases as the absorption increases.

3. The strength of tile, if well burned, varies with the type of raw material used; shales, dense burning fire clays, open burning fire clays, and surface clays generally giving strengths in the order named, although not without marked exceptions.

4. The unit strength on net area of end construction tile when tested on edge is, as based on average values, 65% of that obtained when the tile is tested on end, or as based on gross area the strength when tested on edge is 38% of that obtained when tested on end. This is offset to some extent by the fact that the efficiency of the unit in the wall is greater when laid on edge than when laid on end.

5. With well burned tile, there is a fairly definite relation between absorption and strength. This relation is not linear, the curve shows an increasing gain in strength with a decrease in absorption.

6. Color cannot be taken as indicative of strength because of the many kinds of clay used in the tile industry.

7. The modulus of elasticity varies from 1,600,000 to 6,060,000 pounds per square inch approximately directly with the strength and inversely with the absorption.

8. An absorption of 16%, apparently marks a very definite line in the resistance to freezing and thawing. Tile of lower absorption showed little or no effects from 100 freezings and thawings while tile of higher absorptions incurred loss from the loosening and falling away of small spalls and were appreciably weakened.

Acknowledgments

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Bureau of Standards
Washington, D. C.

HOW TO GET RID OF SCUM ON A TANK MELTING FLINT BOTTLE GLASS[1]

By J. William Gayner

Scum which is commonly known to the layman in glass houses is quite a bothersome affair as it curtails the melting tonnage of the tank and also has a tendency to seed and streak the glass.

I would not undertake explaining what makes scum, as I do not know. I have heard this question discussed by many able glass men and they vary in opinion. One claims it comes from the soda, another from the lime, and another from lowering the temperature of the furnace on Saturday and Sunday blocks. In general practice these few things, which I will enumerate, help to get rid of scum.

Old Lime.—It is oftentimes the practice to let the fresh lime be dumped in the bin on top of the old lime, consequently the old lime is losing its strength, and then when the lime gets low, they will go back and get this old lime in the back of the bin which has been laying there for a long time. I have made a practice of using the old lime before we start using the new lime.

Old Soda.—The same thing holds good in regard to soda. By having twin bins or shoveling the old shipment forward, before the new shipment is unloaded on the old, will keep these materials in better condition.

Irregular Furnace Operation.—I think the greatest cause is the irregular running of the furnace, allowing the furnace to get cold Saturday nights and Sunday, and then bringing it up quickly so as to be ready for work on Monday.

I have tried to avoid these conditions, but even so I have scum on the tank. A simple method, which I am going to try to explain, has been a big help to me for a number of years.

I have a couple of men Sunday morning open the skimming hole just before the bridge in the melting pot. The furnace will be lower in temperature, so they can skim off all the dross, rough matter and scum. By so doing each Sunday morning, we keep rid of the scum. I realize that the bridges in some furnaces are so constructed that it is impossible to have the skimming hole so arranged as to do what I have described, but my practice is always to push the bridge away from the last port so as to have room for the skimming hole.

Lynchburg, Virginia

[1] Presented at the Atlantic City Meeting, February, 1924. (Glass Division.)

REFRACTORY CLAYS AND SHALES OF INDIANA[1]

By W. N. Logan[2]

The refractory ceramic materials of Indiana are obtained from kaolin (halloysite or Indianaite), from fire clays or under clays, and from shales. The halloysite deposits occur largely at the contact between the Pottsville (Mansfield) sandstone and aluminous shales of the Chester group of the Mississippian, but minor deposits also occur at the contact of Chester shales and sandstones.

The fire clays are found in the Coal Measures or Pennsylvanian rocks. They are generally present beneath beds of coal but sometimes they are found unassociated with coals.

Some of the shales of the Chester group contain a high per cent of aluminium, only a small per cent of fluxing impurities, and, as a result, exhibit a moderately high degree of refractoriness.

Preparatory treatment of these last two sources of Indiana refractories have, in some samples at least, increased the degree of refractoriness. For example, weathering and washing of some of the under clays and some of the shales have increased their refractoriness.

Geographical Distribution.—All of these refractory substances are found in the western and in the southwestern portions of Indiana. The largest kaolin deposits have been found in Lawrence County but other deposits occur in Owen, Monroe, Greene, Martin and Orange counties.

The under clays are found in twenty-six counties of the state. They occur in the counties mentioned below and in the vicinity lying west of these counties. The Chester shales outcrop east of the outcrop of the Coal Measures in Perry, Crawford, Orange, Martin, Lawrence, Monroe, Greene, Owen and Putnam counties.

To the beds of white Indiana kaolin Cox gave the name "Indianaite." The principal part of the deposit is halloysite though allophane and gibbsite are also present.

Physical Properties.—The pure halloysite is a white substance of porcelain-like appearance. When first taken from the deposit it often exhibits a pale sea-green color and is semi-translucent. After exposure to the air, it loses its green color and becomes opaque-white. The large fragments of kaolin break up into irregular particles which do not pass readily into the plastic state but even when reduced to a fine condition possess only a moderate degree of plasticity.

The kaolin of the deposit is porous and when dry contains much air. The per cent of absorption of water by weight varies from 6.6 to 13.

The kaolin fragments contain plane surfaces which correspond to cleav-

[1] Recd. Dec. 14, 1923. Presented at the Atlantic City Meeting, February, 1924. (Refractories Division.)

[2] State Geologist.

age planes but there is no regular cleavage system. The fracture in some fragments is distinctly conchoidal. The average hardness is about 2.5. However, there is a soft putty-like variety which hardens on exposure to the air. The specific gravity varies from 2 to 2.33.

Under the microscope the white kaolin is seen to be composed of minute globular granules which are often arranged in a dendritic form. These granules are translucent in appearance and have about the same index of refraction as balsam. The field sometimes contains larger structures composed of concentric rings of granules.

Chemical Properties.—The theoretical composition of halloysite is: silica, 43.5, alumina, 36.9, and water 19.6. Allophane has the composition: silica 20, alumina 40, and water 20.

The average of three analyses of the Indiana halloysite exhibits silica 39.08 parts, alumina 36.58, and water 23.33. The average impurities are only .35 parts.

The fusion point of the white kaolin ranges from 3300°F to 3400°F. The presence of iron, manganese and other elements in the stained kaolin reduces the fusion point.

Under Clays (Fire Clays)

The so-called "fire clays" of Indiana are associated with the coal-bearing rocks of the Pennsylvanian Period. There are about thirty-five beds of coal in the state and there are fire clays associated with the larger number of these. In addition there are some workable beds of fire clay not associated with coal. The clays underlying the following coals have been used extensively for ceramic purposes; Upper Block, Minshall, III, IIIa, and V. The under clays of other coals have been used less extensively.

Physical Properties.—The fire clays have an excellent degree of plasticity, are fine of grain, and are free from concretions or particles which are likely to cause imperfections in ceramic wares. They are grey in color, imperfectly laminated, and have a smooth, soap-like feel. They are often irregularly jointed, and slicken-sided surfaces are often present. At high temperatures they burn to a grey color, and the ware is generally free from cracks or crazes.

Analysis of Minshall Clay

	Per cent		Per cent
Loss on ignition	10.64	Iron oxide	1.92
Magnesium oxide	0.00	Silicon dioxide	58.90
Calcium oxide	0.76	Sulphur trioxide	1.31
Titanium oxide	1.40	Potassium oxide	0.48
Aluminium oxide	25.04	Sodium oxide	0.18
Total			100.63

Chemical Composition.—The chemical composition of the fire clays is variable. Variations occur as between beds and in individual beds. The per cent of alumina is usually between 20 and 25; the silica between 58 and 65; the fluxes from 3 to 4; and loss on ignition from 7 to 10. The table gives the analysis of a fire clay from beneath the Minshall coal.

Uses.—Fire brick have been manufactured from the under clays in a number of plants in Indiana. The brick were used largely for lining kilns and fire boxes, locally. The Simpson Brick Company located near Carbon have been manufacturing fire brick for many years. The brick are made from a mixture of the clay underlying Upper Block Coal and ganister. Both materials are obtained at the plant as the ganister occurs above the coal. The brick are placed upon the market. Other fire clay producing concerns in Indiana have sold clay which has been used elsewhere in the manufacture of refractories.

The writer has experimented with mixtures of Indiana under clays and halloysite, and has found that a very satisfactory high-grade refractory may thus be obtained. The fusion point of such mixtures varies from 3000°F to above 3300°F.

During a portion of the world war period a St. Louis firm manufactured a refractory called "Malinite." The material consisted of a mixture of Indiana halloysite and fire clay. Three samples of the Malinite were tested by R. W. Hunt and Company of Chicago as follows:

Three samples of Malinite refractories were selected, one white, one mottled and one brown. Portions of these brick were cut out and shaped into cones and mounted into a pat of Malinite, together with pyrometric cones numbered 30, 32, 34, 35, 36, 37, 38 and 39. After drying, the pat holding the pyrometric cones and test pieces was placed in an electric furnace of Hoskins manufacture, the current turned on and heating continued until the melting of cone 39.

The tests were started about 2:30 P.M. the same date. The atmosphere of the surface was reducing. The tests were conducted in the presence of J. H. Campbell, A. Malinovsky and W. W. Ittner. On August 22nd, the pat was taken from the furnace and the specimen of brick examined. There was no indication of fusion on the three samples tested. The temperature reached was 3542°F or better.

Load Tests under Heat

Full specimens of brick were placed in a furnace and heated up to 1350°C, about 2500°F in a period of $4^1/_2$ hours, and held at that temperature for $1^1/_2$ hours. Specimens were allowed to cool in the furnace over night. As tested the brick was set on end and a load of 25 pounds per square inch applied during the heating and cooling, as provided by specification of the American Society of Testing Materials C 16–17 T.

Description of sample	Mottled	Brown
Dimensions under compression.....	2.50 in. x 4.56 in.	2.55 in. x 4.50 in.
Height as tested.....	9.35 in.	9.43 in.
Area under compression.....	11.40 sq. in.	11.47 sq. in.
Total load applied.....	285 lbs.	287 lbs.
Load per square inch.....	25 lbs.	25 lbs.
Height after test.....	9.34 in.	9.34 in.
Per cent contraction.....	11/100	None

Neither sample showed signs of checking after the above test.

Cold Crushing Test

Description of sample	Mottled		Brown	
Test number	1	2	3	4
Specimen tested..	On end	Flat	On end	Flat
Dimensions under compression...	2.56″ x 4.66″	9.37″ x 4.54″	2.45″ x 4.59″	9.39″ x 4.54″
Area under compression.....	11.93 sq. in.	42.54 sq. in.	11.25 sq. in.	42.63 sq. in.
Height as tested.	9.42 in.	2.49 in.	9.31 in.	2.50 in.
Maximum load..	16,750 lbs.	92,290 lbs.	12,430 lbs.	73,680 lbs.
Crushing strength (lbs. per sq. in.)	1,404 lbs.	2,170 lbs.	1,105 lbs.	1,705 lbs.
Failure.....	Regular	Regular	Regular	Regular

Slagging Test

Specimens were heated to 1350°C, 2500°F, in a period of five hours. 12.6 grams of basic open hearth slag were then placed in the cavity previously prepared in the samples and held at the above temperature for two hours and allowed to cool in the furnace. Size of cavity, $1^{5}/_{8}$ in. diameter by $^{9}/_{16}$ in. depth.

Description of sample	Mottled	Brown
Slag used	Basic Open Hearth	...
Slag penetration, sq. in.	0.57	0.48

A test was made on each sample, using powdered silica brick and powdered magnesia brick. These materials showed no penetration under the above test.

The above slagging test is practically in compliance with the specification of the American Society of Testing Materials C 17–17 T, except the weight of slag and diameter of cavity. This was changed in order to permit the placing of three specimens in the furnace under the same conditions at the same time.

Chemical Analysis

Chemical analysis of portions of the three specimens subjected to fusion tests follows:

	White	Per cent mottled	Brown
Silica	44.90	46.62	47.50
Iron Oxide	0.71	0.71	4.60
Aluminum Oxide	52.39	50.91	46.36
Calcium Oxide	1.12	1.16	0.60
Magnesium Oxide	0.28	None	None
Sodium Oxide	0.04	0.24	0.26
Potassium Oxide	None	Trace	0.09
Titanium Oxide	0.10	0.28	0.60

Transverse Test

A transverse test was made on two samples of each, mottled and brown. The average of these two tests are:

Test	No. 1	No. 2
Description of sample	Mottled	Brown
Average dimensions	4.615 x 2.50 x 9.365	4.25 x 2.465 x 9.36
Distance between supports, C to C	8 in.	8 in.
Breadth as tested	4.615	4.425
Depth as tested	2.50	2.465
Maximum load sustained	1.140	1.390
Modulus of rupture	476	621

Specific Gravity

The determination of the specific gravity was made upon two specimens each of mottled and brown, the results of which are:

Test	Mottled No. 1	Brown No. 2
Weight used	60 grams	60 grams
Volume	21.1 cc.	21.1 cc.
Actual specific gravity	2.84	2.83

Conclusion

The above tests indicate a refractory with a very high fusion point and one that under temperature maintains its shape when subjected to pressure. It resists slagging action well, and the uniform penetration of the slag indicates a good mixture of the materials before molding. The absence of slagging with the magnesite brick and silica brick suggest that malinite refractories may be placed in contact with the other refractory materials without slagging action, and that the refractory possesses neutral properties.

Chester Shales

Shales belonging to the Sample, Elwren, Indian Springs, and other divisions of the Chester group of rocks in Indiana have been used for ceramic purposes. The quantity and the quality of the shales vary much in each stratigraphical horizon.

Physical Properties.—The Chester shales usually have a good degree of plasticity. The color is usually grey, greenish grey or maroon. The loss of weight in passing from the wet condition to the vitrified state is about 20%. The color of the more aluminous shales after reaching the vitrified stage is generally grey. The fusion point of the shales as taken from the outcrop of the better grades is from 2500°F to 3300°F. Mixtures of the shales and halloysite exhibit a much higher fusion point.

Chemical Composition.—The analyses of five samples of the Chester shales are given in the following table:

ANALYSES OF SAMPLES OF CHESTER SHALE

Constituents	No. 1, Per cent	No. 2, Per cent	No. 3, Per cent	No. 4, Per cent	No. 5, Per cent
Silica	61.24	64.57	58.40	58.68	59.67
Aluminium Oxide	18.38	18.67	20.70	21.39	19.75
Iron Oxide	4.76	6.22	6.58	6.22	7.32
Calcium Oxide	0.70	0.10	0.15	0.14	0.20
Magnesia	1.94	0.65	0.86	0.82	1.02
Alkalies	3.94	2.62	3.16	2.59	2.42
Loss on ignition	10.04	7.17	8.89	8.90	8.60
Sulphur Tri-oxide	.....	tr.	1.26	1.26	1.02
Total	101.00	100.00	100.00	100.00	100.00

By thoroughly weathering and washing the under clays and Chester shales they may be used in the manufacture of high grade refractories, but a better quality of refractory can be obtained by using a mixture of these clays and halloysite.

BLOOMINGTON, IND.

THE DEAD BURNING OF DOLOMITE.—III[1]

By James Thomas Robson and James R. Withrow

Survey of $Fe_2O_3.Al_2O_3.SiO_2$ Field as Dolomite Fluxes

After the preliminary work, it was decided to run series using $Fe_2O_3.Al_2O_3.SiO_2$ in all proportions that would be practically possible for dead burning dolomite. Four triaxial studies of twenty-two members were made similar to the previous work in 1A blending on the weight basis and using 100-mesh dolomite. Series C consisted of 95% of dolomite + 5% of flux, Series 2A contained 90% of dolomite + 10% of flux, the same as Series 1A. Series D consisted of 85% of dolomite + 15% of flux and Series E consisted of 60% of dolomite + 40% of flux. Series E was made in order to establish the fact that an excess of flux is undesirable. Series 2A was run in order to check up on 1A and also to compare this series with the three new series, it being burned and tested parallel with them.

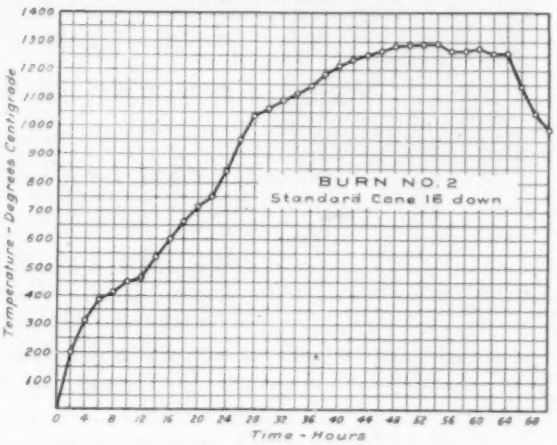

FIG. 18.

The percentage composition of the members of these series is given in Table V. These members were made as previously described for series 1A, using the same oxides as reported.

Six cubes of each member were set on magnesite brick and burned for 64 hours to cone 16 down. The temperature curve for this burn is shown in Fig. 18. The results are shown in Table VI.

As shown by the table, in general the high Fe_2O_3 field had what was termed "normal shrinkage;" the high Al_2O_3 field possessed the greatest shrinkage and the high SiO_2 field, the lowest shrinkage.

In Series C, all of the cubes appeared to be of good density and structure. Those containing Fe_2O_3 possessed a dull coke-like structure and appearance.

In general, the cubes in Series 2A appeared similar to those in Series C.

The cubes containing Fe_2O_3 in Series D appeared to be slightly more dense and vitrified than those in Series 2A. Member D17 had a slag-like appearance due to overfiring, D18 was also glassy due to overfiring. Members

[1] Published by permission of the Director, U. S. Bureau of Mines. See "The Dead Burning of Dolomite.—I," *Jour. Amer. Ceram. Soc.*, **7** [1], 61 (1924).

TABLE V

Member	Series C 5% Flux, 95% Dolomite Fe_2O_3 per cent	Al_2O_3 per cent	SiO_2 per cent	Series 2A 10% Flux, 90% Dolomite Fe_2O_3 per cent	Al_2O_3 per cent	SiO_2 per cent	Series D 15% Flux, 85% Dolomite Fe_2O_3 per cent	Al_2O_3 per cent	SiO_2 per cent	Series E 40% Flux, 60% Dolomite Fe_2O_3 per cent	Al_2O_3 per cent	SiO_2 per cent
1	5	.	.	10	..	..	15	..	..	40	..	..
2	4	1	.	8	2	..	12	3	..	32	8	..
3	4	.	1	8	..	2	12	..	3	32	..	8
4	3	2	.	6	4	..	9	6	..	24	16	..
5	3	1	1	6	2	2	9	3	3	24	8	8
6	3	.	2	6	..	4	9	..	6	24	..	16
7	2	3	.	4	6	..	6	9	..	16	24	.. ..
8	2	2	1	4	4	2	6	6	3	16	16	8
9	2	1	2	4	2	4	6	3	6	16	8	16
10	2	.	3	4	..	6	6	..	9	16	..	24
11	1.67	1.67	1.67	3.33	3.33	3.33	5	5	5	13.33	13.33	13.33
12	1	4	.	2	8	..	3	12	..	8	32	..
13	1	3	1	2	6	2	3	9	3	8	24	8
14	1	2	2	2	4	4	3	6	6	8	16	16
15	1	1	3	2	2	6	3	3	9	8	8	24
16	1	.	4	2	.	8	3	..	12	8	..	32
17	.	5	.	.	10	..	..	15	..	..	40	..
18	.	4	1	.	8	2	..	12	3	..	32	8
19	.	3	2	.	6	4	..	9	6	..	24	16
20	.	2	3	.	4	6	..	6	9	..	16	24
21	.	1	4	.	2	8	..	3	12	..	8	32
22	.	.	5	.	..	10	..	..	15	..	..	40

D20, D21 and D22 slaked down in the kiln due to an excessive amount of SiO_2 which tends to form dicalcium silicate.

The members of Series E all possessed a glassy surface due to overfiring. As shown in Table VI, most of the members of this series were either partially fused or fused down completely. All members were very much overburned showing that 40% of flux is too much for use of the dolomite as a refractory.

Member E19 appeared to be entirely different from any other members studied in that it gave a very white glassy partially fused cube containing long needle-like crystals throughout.

FIG. 19.—Warm water slaking test apparatus.

Tests

The room temperature and outside air slaking tests were run on this series similar to those of the preliminary tests. The hot water test, however, was made more reliable and uniform by using the tank and wire screen basket shown in Fig. 19. This tank contained 47 gallons of water which was maintained constantly at a temperature between 75–85 °C. The level of the water was never allowed to fall below the surface of the basket so that the cubes were continuously immersed.

FIG. 20.—Autoclave.

The hot water test under pressure was run in the autoclave shown in Fig. 20. The cubes were placed in the autoclave, filled with water, and heated up to 21 pounds gage pressure, then removed and examined for signs of slaking or cracking. Those which withstood this test were then taken up to 50 pounds gage pressure, then to 97 pounds and finally to 103 pounds gage pressure which was the maximum pressure obtainable in this autoclave. After each pressure interval, the cubes which showed signs of breaking down or cracking were removed.

Air Slaking Test.—Both the outside and inside air slaking test proved to be of about the same rapidity in the case of Series C. Member C22 was the first to slake after 70 days' exposure at room and outside temperature. It swelled up to about three times its normal size, finally cracking and slaking down to a powder when pressed between the fingers.

Member C16 after exposure for 92 days in the laboratory, bloated to about $1\frac{1}{2}$ times its normal size and cracked badly. After 92 days' ex-

TABLE VI

RESULTS OF BURN AT CONE 16 DOWN

Member	Series C		Series 2A		Series D		Series E	
	Color	Remarks	Color	Remarks	Color	Remarks	Color	Remarks
1	Black	Normal shrinkage	Black	Normal shrinkage	Black	Excessive shrinkage	Reddish brown	Excessive shrinkage
2	Black	Normal shrinkage	Black	Normal shrinkage	Black	Excessive shrinkage	Brown	Excessive shrinkage
3	Black	Normal shrinkage	Black	Normal shrinkage	Black	Excessive shrinkage	Reddish brown	Excessive shrinkage
4	Black	Normal shrinkage	Black	Normal shrinkage	Black	Excessive shrinkage	Black	Excessive shrinkage
5	Black	Normal shrinkage	Black	Normal shrinkage	Black	Excessive shrinkage	Black	Excessive shrinkage
6	Black	Normal shrinkage	Black	Normal shrinkage	Black	Low shrinkage, very porous	Fused down completely	
7	Black	Normal shrinkage	Black	Normal shrinkage	Black	High shrinkage	Black	Partially fused
8	Black	Normal shrinkage	Black	Normal shrinkage	Black	High shrinkage	Dark brown	Partially fused
9	Black	Normal shrinkage	Black	Normal shrinkage	Black	Medium shrinkage	Fused down completely	
10	Black	Normal shrinkage	Black	Normal shrinkage	Black	Medium shrinkage	Fused down completely	
11	Black	Normal shrinkage	Black	Normal shrinkage	Black	Medium shrinkage	Fused down completely	

TABLE VI (*Continued*)

12	Black	Normal shrinkage	Black	Normal shrinkage	Black	High shrinkage	Black	Partially fused
13	Black	Normal shrinkage	Black	Normal shrinkage	Black	High shrinkage	Brown, glassy	Partially fused
14	Black	Normal shrinkage	Black	Normal shrinkage	Black	Medium shrinkage	Fused down completely	
15	Black	Low shrinkage	Black	Low shrinkage	Black	Medium shrinkage	Fused down completely	
16	Brownish black	Low shrinkage	Black	Low shrinkage	Slaked in kiln to brown powder		Brown	Partially fused
17	Light brown	Medium shrinkage	Light brown	High shrinkage	Brown	High shrinkage, very porous	Slaked in kiln to white powder	
18	Light brown	Medium shrinkage	Greenish brown	High shrinkage	Green, glassy	High shrinkage	Slaked in kiln to white powder	
19	Brownish green	Medium shrinkage	Pale green	Medium shrinkage	Pale green	Medium shrinkage	White frosty glass, many needle-like crystals present	
20	Brownish green	Low shrinkage	Green	Low shrinkage	Slaked in kiln		Slaked in kiln to white powder	
21	Green	Low shrinkage	Green	Low shrinkage	Slaked in kiln		Slaked in kiln to white powder	
22	Yellowish green	No shrinkage	Green	Low shrinkage	Slaked in kiln		Slaked in kiln to white powder	

posure outside, it swelled slightly and cracked badly although not as much as did the sample which was left at room temperature. Member C21 swelled and cracked badly after 102 days' exposure both inside and outside, although the sample kept inside swelled slightly more than the outside sample but did not crack as much.

Figure 21 shows these samples together with a cube of the original size before slaking started. The sample of C22 which underwent the outside air slaking test is not shown because it was broken when handled. The three cubes at the top are those which underwent the inside air slaking test, the two in the middle are those of the outside test and the bottom cube is one of original size.

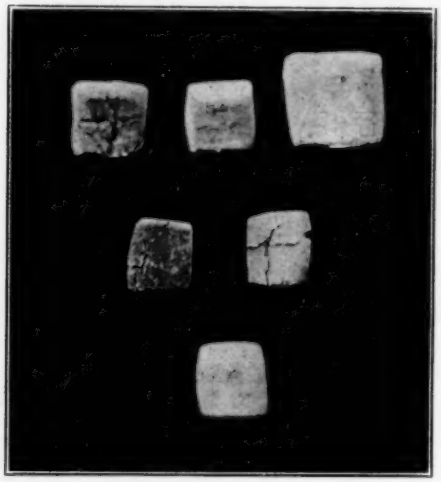

FIG. 21.—Air slaked cubes.

Member C6 slaked inside the room after 131 days but the outside sample has remained O. K. for 150 days.

As shown in Figs. 13 and 14,[1] several cubes in Series 1A had slaked after standing for 131 days, although Series 2A of the same composition had but one member, 2A1, which slaked both inside and outside after 131 days. After 150 days no other cubes in this series have slaked. This is probably due to the difference in atmospheric conditions. Series 1A was exposed during the summer months when the humidity is high, while Series 2A has been exposed during the winter months of low humidity.

In Series D, Members D15 and D4 have slaked after 131 days' exposure inside. No other member of this series has slaked after 150 days' exposure.

No member of Series E has slaked after 150 days' exposure.

Warm Water Slaking Test.—The results of this test are shown in Table VII and Figs. 22, 23, and 24.

Series C. –In the hot water slaking test, but two members, C18 and C19, appear to be reasonably stable. C18 withstood this test for 11 hours and C19 for 21 hours. Evidently 5% of flux does not give a very wide field of stability. See Fig. 22.

Series 2A.—As shown in Fig. 23, 2A13 and 2A20 were stable for 13 days. 2A15 stood up for 21 days and again as in the preliminary run,

[1] See "The Dead Burning of Dolomite.—II," *Jour. Amer. Ceram. Soc.*, **7** [2], 144, 145(1924).

TABLE VII
WARM WATER SLAKING TEST
Number of Days before Slaking

Member	Series C	Series 2A	Series D	Series E
1	1	1	1	9
2	1	1	2	9
3	1	1	2	21
4	1	1	1	2
5	1	1	2	13
6	1	1	OK after 130 days	Slaked in kiln
7	1	1	1	Slaked in kiln
8	1	1	2	13
9	1	2	75	Slaked in kiln
10	1	2	13	Slaked in kiln
11	1	2	26	Slaked in kiln
12	1	4	9	Slaked in kiln
13	1	13	32	32
14	2	24	13	Slaked in kiln
15	1	21	50	Slaked in kiln
16	1	1	Slaked in kiln	Slaked in kiln
17	3	2	2	Slaked in kiln
18	11	2	21	Slaked in kiln
19	21	5	OK after 130 days	Slaked in kiln
20	1	13	Slaked in kiln	Slaked in kiln
21	1	2	Slaked in kiln	Slaked in kiln
22	1	2	Slaked in kiln	Slaked in kiln

Member 2A14 was the most stable member of the series, slaking after undergoing the test for 24 days.

This test is no doubt more severe than the boiling test conducted in the preliminary run where Member A14 withstood the test for 99 days.

In general, the field around Members 14, 15 and 20 appears to be the most stable as in the case in Series 1A.

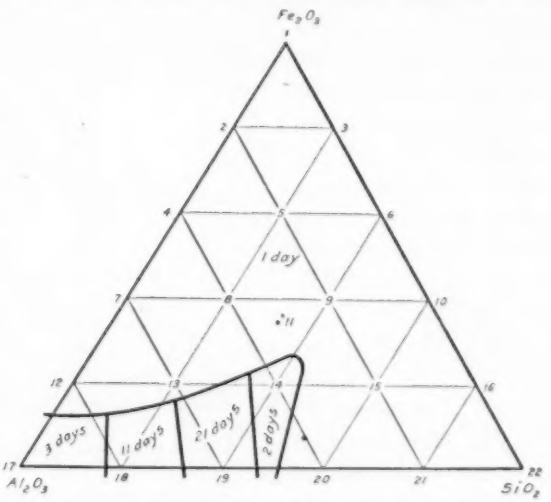

FIG. 22.—Warm water slaking test of Series C.

Series D.—Figure 24 shows that this series possesses a larger field of stability than series C and 2A. The field of low stability in this test lies on the Fe_2O_3.Al_2O_3 side especially in the high Fe_2O_3 region. The most stable field lies through

the center of the diagram away from the apices, the most stable members being D6 and D19 which showed no signs of decomposition after 130 days.

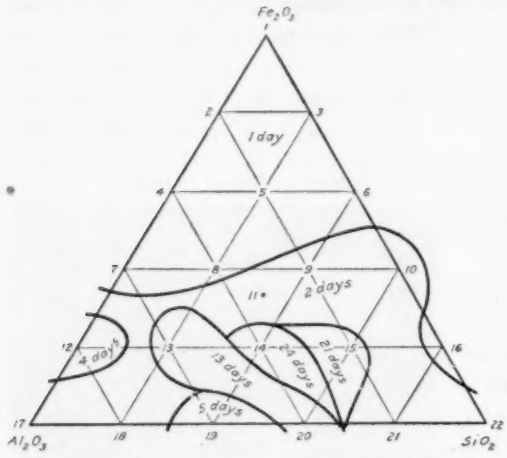

FIG. 23.—Warm water slaking test of Series 2A.

In this series there are seven stable members which underwent this test for more than 20 days. The extreme end members as in the other series, were very unstable.

Series E.—In this series, Member E1 stood up for 9 days, E3 was stable for 21 days, E5 and E8 did not slake until after 13 days and E13 stood up for 32 days. Member E19 withstood this test and did not slake after being subjected to this test for 130 days. As previously explained, E19 was partially fused at cone 16 so that it would probably be of no use as a refractory. Also, as previously shown, Member D19 failed to slake after 130 days test in warm water.

Because of the few members obtained in this burn, no definite conclusions on this test can be drawn. However, the tendency seems to be that the region high in Fe_2O_3 is again the most unstable.

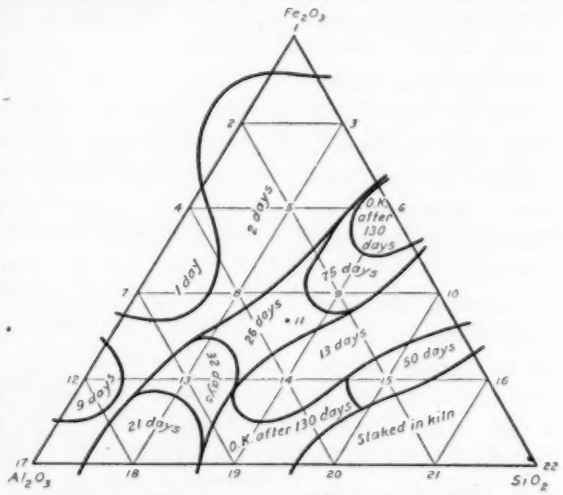

FIG. 24.—Warm water slaking test of Series D.

Hot Water Test under Pressure.—The results of this test are shown in Table VIII and Figs. 25, 26, 27.

Series C.—The results of this test on Series C are shown in Fig. 25. Here it is seen as in the other slaking tests, the most unstable area is in the high Fe_2O_3 field. The members in the low Fe_2O_3 region toward the Al_2O_3 field appear to be the most stable, Members C13, C14 and C17 did not slake when the gage pressure reached 103 pounds per square inch.

Series 2A.—The results for this series are shown in Fig. 26. The unstable field in this series is somewhat smaller than that in Series C but again lies in the high Fe_2O_3 area, the stable members lying in the low Fe_2O_3 field.

The Al_2O_3 content by itself, 10% in 2A17, seems to render the dolomite more unstable than did 5% Al_2O_3 in Member C17. Member 2A17 slaked down at 21 pounds pressure whereas C17 did not slake at the maximum pressure used, namely 103 pounds per square inch.

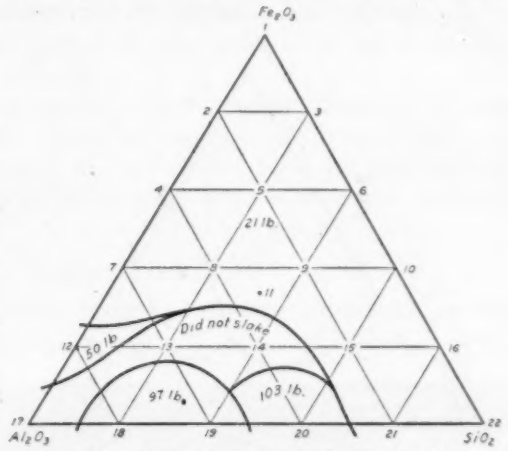

FIG. 25.—Hot water pressure test of Series C.

Although Member 2A17 is not included in the most stable area which did not slake in this series, the stable field is larger than that in Series C as will be seen by reference to Figs. 25 and 26.

TABLE VIII

HOT WATER SLAKING TEST UNDER PRESSURE

Number of pounds steam gage pressure applied before slaking

Member	Series C	Series 2A	Series D	Series E
1	21	21	21	21
2	21	21	Did not slake	Did not slake
3	21	21	Did not slake	..
4	21	21	21	50
5	21	21	97	Did not slake
6	21	97	Did not slake	..
7	21	21	21	..
8	21	21	Did not slake	97
9	21	97	Did not slake	..
10	21	Did not slake	Did not slake	..
11	21	21	Did not slake	..
12	50	Did not slake	97	..
13	Did not slake	Did not slake	Did not slake	Did not slake
14	Did not slake	Did not slake	Did not slake	..
15	21	Did not slake	Did not slake	..
16	21	21	Slaked in kiln	..
17	Did not slake	21	21	..
18	97	97	Did not slake	..
19	97	97	Did not slake	103
20	103	103	Slaked in kiln	..
21	21	97	Slaked in kiln	..
22	21	50	Slaked in kiln	..

The stable field lies mostly below the 4% Fe_2O_3 of total flux line as is the case in Series C.

The extreme end members are very unstable under this test.

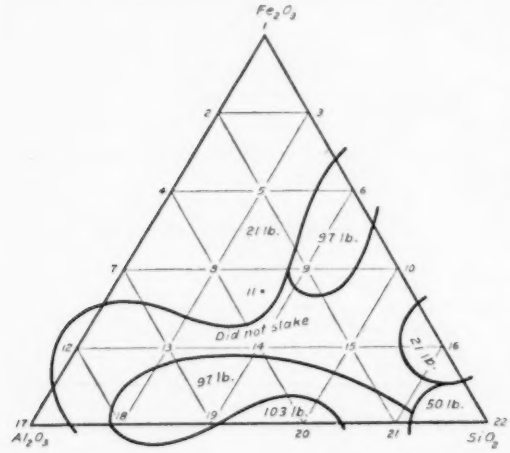

FIG. 26.—Hot water pressure test of Series 2A.

Series D.—Fig. 27 shows that 15% flux gives a much larger field of stability than 10% of flux as in Series A. The end members again appear to be very unstable.

Except in Member 2A2, it appears that at least a small amount of SiO_2 is required with the fluxes in order to make a stable composition.

As was the case in both Series C and Series 2A, Members D13 and D14 did not slake when the maximum pressure of 103 pounds per square inch was attained.

General Conclusions of Slaking Tests

In all series in these tests except in the test under pressure, two cubes of each member were tested and in every case both cubes slaked together, showing the results to be reliable. Wherever two cubes were used in the tests under pressure, they likewise slaked down together.

It will be noted that as the amount of flux increases, the area of the field of stability becomes larger so that, in general, increase in the amount of flux increases the stability of the dolomite.

Increase in amount of flux not only increases the area of the field of stability, but also the degree or length

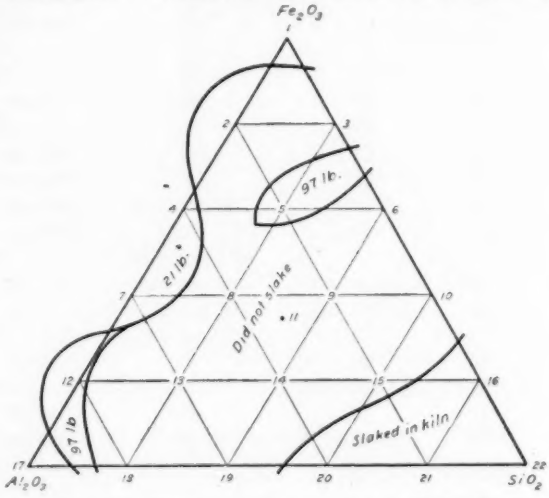

FIG. 27.—Hot water pressure test of Series D.

of time of stability, *e. g.*, the most stable member in Series C stood up in the warm water slaking test for 21 days, in Series 2A for 24 days and in Series D for more than 100 days.

Pure Fe_2O_3, pure Al_2O_3 or pure SiO_2 when used alone are of no value as fluxes for dead burning dolomite.

D6 containing only Fe_2O_3 and SiO_2 is very stable, likewise D19 containing only Al_2O_3 and SiO_2 is extremely stable. E19 is very stable, but it contains 40% of fluxes which, as shown later, have too great an effect on lowering the fusion temperature of dolomite to be used as a refractory.

Fusion Tests

Having determined the field of stability of these oxides as fluxes for dead burning dolomite, it was decided to make a study of the effect of these fluxes on the refractoriness of dolomite in order to determine what stable compounds appear plausible for using as refractories.

a *b*

FIG. 28.—Arrangement of cone plaques.

The ordinary cone fusion tests were run on all members of the three series, C, 2A and D. Since Series E appeared to be impracticable for commercial use because of its low fusing temperature as previously described, it was discarded from further work.

These dolomite cones fluxed violently at about cone 26 or lower when placed in the ordinary cone plaques made of sillimanite, bauxite or kaolin; so that it was found necessary to use two cone plaques for each burn. One plaque was made of calcined magnesite to hold the dolomite cones and for the standard cones an ordinary plaque of the following composition:

Florida kaolin	70%
Refined alumina	30%

This composition was tempered with water, formed into plaques, dried and calcined at cone 9.

The standard cones could not be placed in the magnesite plaque containing the dolomite cones, since it was found that they fluxed with magnesite at about cone 26 or lower.

The magnesite plaques were made of calcined magnesite. They were about $1^3/_4 \times {}^1/_2 \times {}^3/_8$ inches. Three holes about $^3/_{16}$-inch deep for holding cones were made in each plaque. These were calcined at about cone 8.

For preliminary tests in order to determine the approximate fusion temperature of the dolomite mixtures, ordinary round plaques 2 inches in diameter by $^3/_8$-inch deep with holes $^1/_8$-inch deep containing 8 standard cones ranging from cone 11 to cone 32 were made. These cones were varied with the different fields studied. These round plaques containing the standard cones together with a rectangular magnesite plaque containing three dolomite cones of different composition were placed together, side by side, on a magnesite block in a three-burner compressed air-gas pot furnace. These plaques together with their arrangement are shown in *a*, Figure 28. The furnace used is shown in Fig. 29.

The check determinations were run using 3 standard cones which were set in a sector broken from the ordinary round plaques. These sectors were about $^1/_2$-inch wide at the center. In many cases, two plaques of dolomite cones with the standard plaque placed between them were used. See *b*, Fig. 28.

The standard cones were held in place in the plaques with alumina powder. The dolomite mixture cones were held in place by powdered 100-mesh calcined magnesite. In order to prevent tipping of the cones, the magnesite powder was thoroughly tamped into the hole around the cone and then built up around it about $^1/_4$ inch high in order to fill the space formed due to greater contraction, during burning of the dolomite cones in comparison with the magnesite plaques containing them and also due to shrinkage of the magnesite powder itself.

FIG. 29.—Fusion test furnace.

After these details had been adhered to, no trouble was experienced in running these tests.

In many instances, two cones of the same composition were placed in the same plaque and also during checking, cones of similar composition were placed in each of the two opposite plaques in order to assure that the temperature condition in the furnace was the same over the entire area covered by the three small plaques, which, as shown in *b*, Fig. 28, really occupied no wider area than the two plaques used in the preliminary tests.

Also, in several cases, a magnesite plaque containing dolomite cones was placed between two plaques of similar standard cones in order to frequently check on the uniformity of heat in the furnace. Cone 32 was the maximum temperature used in these tests, because of the excessive wear and tear on the furnace at temperatures higher than cone 32.

The cones used in these tests measured $1^1/_2$ inches in length, being made in the standard size cone mold and cut to this length. The standard cones below number 26 were also cut to this length.

Results of Fusion Tests

Series C.—Pure dolomite did not start to deform at standard cone 32 down. In Series C, all cones were standing straight up at cone 32 down, showing that 5% of these fluxes does not harm the deformation point of this dolomite.

Series 2A.—The deformation results in series 2A are shown on the triaxial diagram, Fig. 24. The shapes of these dolomite cones, when the standard cones numbered directly below were down, are shown on the diagram. Here it is seen that 10% of Fe_2O_3, alone as a flux, caused the dolomite to assume a position of about two o'clock at standard cone 32 down.

Member 17 consisting of 10% Al_2O_3 was the softest member of the series, it was down at standard cone 15 down. It started to deform with standard cone 12.

Member 22 containing 10% SiO_2 did not start to deform at standard cone 32 down.

There is no single eutectic mixture apparent between the three fluxes in this series, as the diagram shows. The high Al_2O_3 field appears to be the softest, the high Fe_2O_3 field next and the SiO_2 field is the hardest.

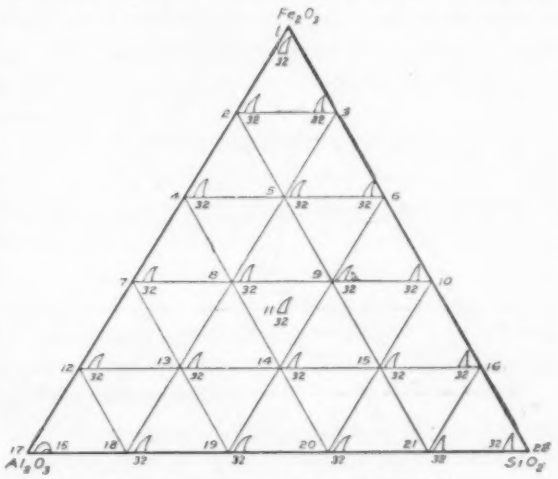

FIG. 30.—Fusion tests of Series 2A.

In every case where the cones stood at about two o'clock when standard cone 32 was down, the dolomite mixture cones started to bend between standard cones 20 and 23. After cone 26 was down, no further bending took place. This is probably explained by the fact that there was a sufficient amount of eutectic or low-melting mixture of fluxes present, to take enough dolomite into solution to cause the small tip at the top to lose shape and start bending, but the small amount of flux was not sufficiently active to cause the entire mass of dolomite to deform.

A study of the four component systems made up from the 3 component systems CaO–MgO–SiO_2; MgO–Al_2O_3–SiO_2; CaO–Al_2O_3–SiO_2 and CaO–MgO–Al_2O_3 given in the introduction, shows that it is to be expected that Al_2O_3 would have a more powerful solution action on the dolomite, because of the small field of stability of Al_2O_3.

The members along line 1–22 of zero Al_2O_3 in Fig. 30 show that Fe_2O_3

softens the mixture more than SiO_2 since 2A16 and 2A22 are perfectly straight up at cone 32 down while cone 10 is very nearly straight up and cones 2A1, 2A3, and 2A6 are about 2 o'clock at cone 32 down.

The line 2–21 in Fig. 30 shows that 2% Al_2O_3 in the presence of 8% of the other two oxides Fe_2O_3 and SiO_2 has about the same effect on the deformation temperature of dolomite as has 8% Al_2O_3 plus 2% of the oxides Fe_2O_3 and SiO_2 except in the case of 2A21 which has barely started to deform. Member 2A17 which contained 10% Al_2O_3 alone as previously mentioned, is much softer than the other members including 2A12 which contains 8% Al_2O_3 plus 2% Fe_2O_3 and Member 2A18 which contains 8% Al_2O_3 plus 2% SiO_2. This shows that 2% Fe_2O_3 or 2% SiO_2 has a decided hardening effect on Al_2O_3 as a flux for dolomite. Also since Member 17 in Series C was straight up at standard cone 32 down, the Al_2O_3 must be present in quantities over 5% before lowering this dolomite below a refractory of No. 1 grade.

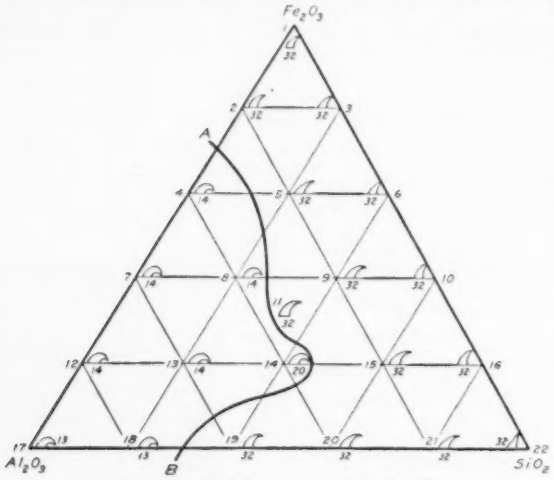

FIG. 31.—Fusion tests of Series D.

Series D.—The deformation results in series D which consist of 15% flux plus 85% of dolomite are shown in the triaxial diagram, Fig. 31.

Member D1 containing 15% of Fe_2O_3 as a flux had a position of very nearly three o'clock at standard cone 32 down.

Member D22 containing 15% of SiO_2 alone as a flux again proved to be the most refractory, being very nearly straight up after standard cone 32 was down.

Likewise, as in Series 2A, Member D17 containing 15% Al_2O_3 was again the softest, being down when standard cone 13 was down.

This series compares with Series 2A in that the high SiO_2 is again the hardest, the high Fe_2O_3 field the next and the high Al_2O_3 field the softest.

By comparing the members of this series in the Al_2O_3 field to the left of line AB of the diagram, with similar members in Series 2A, it can be seen that 15% of flux where Al_2O_3 is present, has a much greater effect on the deformation temperature of dolomite than has 10% of these fluxes. All members in this region were down from standard cone 13 through standard cone 20 down.

Members D17 and D18 came down together, both started to bend when standard cone 10 was just down. Member D12 was slightly slower in deforming than Members D17 and D18.

The members to the right of line AB practically all started to bend between standard cones 20–23 down. After cone 26 was down, no visible deformation took place.

Figure 10[1] shows that 10% of SiO_2 lowers the fusion temperature of pure CaO.MgO from about 2380°C to about 2280°C and 15% SiO_2 lowers the fusion temperature to about 2200°C. Likewise, Fig. 9 shows that 10% Al_2O_3 lowers the fusion temperature of CaO.MgO from about 2380°C to only 2330°C and 15% Al_2O_3 lowers the fusion temperature to only about 2290°C. Comparing this action of SiO_2 and Al_2O_3, it is evident that 10% and 15% SiO_2 lowered the fusion point of pure CaO.MgO more than does 10% and 15% Al_2O_3, respectively. These curves cannot therefore be used comparatively as a criterion of the effect of these amounts of fluxes on the lowering of the deformation point of the dolomite studied herein since, as shown, Al_2O_3 has much greater effect in lowering the deformation of this dolomite than has SiO_2.

Since 15% of SiO_2, Member D22, had apparently no effect on the deformation of this dolomite, it may be that the fusion curve of the effect of SiO_2 on pure CaO.MgO may agree very closely with that showing the effect of SiO_2 on the deformation of this dolomite if this curve would have been determined by using sufficiently high temperatures.

Several members in each series of C, 2A and D were previously calcined to cone 5 and their deformation temperature determined. In all cases the deformation temperature found was the same as when the corresponding raw cones were tested for deformation.

In Series D where 15% of flux was used, there was a tendency for some of the members in the high SiO_2 field to form dicalcium silicate and hence decompose. Immediately after removing Members D16 and D21 from the pot furnace after heating to either cone 26 or cone 32, about $^1/_8$-inch of the top popped off the cone and the rest of it immediately slaked down into a fine powder. This happened in every case when these cones were removed from the furnace. Member D22 which contains 15% of SiO_2 alone as a flux did not slake as soon as D16 or D21 after heating to cone 26, but did slake after standing over night, evidently the formation of $2CaO.SiO_2$ was hastened by the presence of 3% Al_2O_3 or 3% Fe_2O_3.

(To be continued)

[1] See "The Dead Burning of Dolomite.—I," *Jour. Amer. Ceram. Soc.*, **7** [1], 71 (1924).

¶ Members of the American Ceramic Society plan to take the Western Trip for the Summer Meeting, July 21 to August 16.

For particulars write the Secretary's Office, Lord Hall, O. S. U., Columbus, Ohio, or Fred B. Ortman, Tropico Potteries, Glendale, Calif.

CERAMIC ABSTRACTS

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[1] The abbreviation (*C. A.*) at the end of an abstract indicates that the abstract was secured from the Editor of *Chemical Abstracts* by coöperative agreement.

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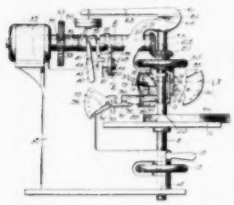
Abrasives

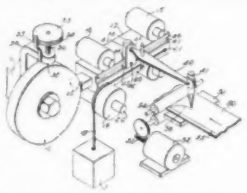
Abrasives. ANON. *Mineral Ind.*, **31**, 1–7(1922).—A review of the abrasives industry. A. B. (*C. A.*)

PATENTS

Method of and apparatus for grading. CHARLES J. HUDSON and WILSON C. BROGA. U. S. 1,478,335. Dec. 18.—The method of grading an article of bonded abrasive grains which comprises relatively moving a wearable tool and said article in contact through an extensive circular path and thereby abrading the tool by the action of successive abrasive grains, simultaneously feeding the tool forward under a definite press., continuing said relative movement for a definite period and until a measurable reduction in tool size has been produced, and measg. the combined amts. of wear upon the article and the tool produced by such abrasion.



Process and apparatus for classifying grinding wheels. CHARLES E. GILLETT. U. S. 1,478,333, Dec. 18. The method of classifying a grinding wheel comprising the steps of rotating the wheel at a normal grinding velocity, grinding a standard wearable tool thereby under uniform press. and for a definite period, making successive determinations of the grinding effect of the wheel on the tool as the opern. proceeds, measg. the wheel wear produced in the time interval, and from the grinding characteristics thus observed classifying the wheel by comparison with data obtained with standard wheels



Art

Color measurement by the Ostwald method. ISMAR GINSBERG. *Textile World*, **64**, 1519–21, 1539(1923); cf. *C. A.*, **17**, 2384.—The practical application of the Ostwald theory to color analysis and the detn. of color purity are discussed. The convenience of the method in designating colors and defining fastness is pointed out. A description of the app. is given. C. E. M. (*C. A.*)

Cement, Lime and Plaster

Continuous automatic shaft kiln for cement plants. F. DEM. TUBMAN. *Rock Products*, **26** [25], 20(1923).—Successful European practice is described, largely the Buhler system. Fuel, coke breeze or anthracite of pea size, and raw mat. are weighed, mixed, moistened with the detd. amt. of water, and briquetted. The briquettes push each other over a bridge to a movable feeding and distributing device. The kilns range to 9 ft. internal diam. with walls of ordinary mat. to 26 ft. in height. Forced draft of approx. 200 mm. water is used, and an output of 45 tons per 24 hrs. with the 9 ft. kiln is obtained. Discharge is secured at the bottom of the shaft by means of a

ribbed cone, toothed rolls, or preferably by a Buhler toothed rasp or ram moving horizontally, and actuated hydraulically giving an even discharge. The clinker is then removed through air locks, and conveyed to storage. Fuel econ., low power consumption in opern., less and easier repairing of kiln, flexibility of opern., ability to stop kiln for any period to 24 hrs., space econ., better and quicker pulverizing of clinker, and excellent quality cement requiring low gypsum content are advantages claimed for product over that of rotary kiln. C. R.

Lime-kiln thermal efficiency. V. J. Azbe. *Rock Products*, **26** [16], 35(1923).—The percentages of CO_2, O_2, and CO in the waste gases, together with the temperature of the gas, and a knowledge of the fuel used are made the basis for the calcns. The tons of lime per ton of coal, and the thermal efficiency of the kiln are calcd. in the usual manner. The greatest ht. loss is due to escape of waste gases at a high temp. either incompletely burned, or with a large amt. of excess air, and can be more readily controlled than losses due to radiation, ht. in burned lime, moisture, etc. Excess O_2 over 2% means that the excess air carries off sensible ht., overloads the gas carrying capacity of the kiln, reduces the kiln temp. and ht. transfer, and reduces the output. In opern. of lime kiln a better proportioning of air and fuel, more regularity, more uniformly sized rock, and better charging are needed. Graphs are furnished for tons of lime per ton of coal, thermal efficiency, fuel loss due to escape of waste products (dry), withdrawal of hot lime, and incomplete combustion, and loss of lime due to too great amt. of excess air. C. R.

The spontaneous disintegration of cement clinker on cooling in the air. J. Dautrebande. *Le Ciment*, **28**, 355–60(1923).—It is maintained that the disintegrating of cement clinker in air is due to the formation of bicalcium silicate ($2CaO.SiO_2$), and that this compd. may be formed not only as the result of an excess of silica for the formation of tricalcium silicate ($3CaO.SiO)_2$, but also from insufficient burning, and from overburning of the charge. The causes for disintegration may be subdivided as follows: (A) **Clinker partially reduced to powder**.—(1) Silica content of the fine powder much higher than that in the lump clinker. (Analyses I.) This may result (*a*) from segrega-

	I		III	II	
	Lump clinker	Powder		Lump clinker	Powder
SiO_2	25.10%	29.16%	28.38%	22.45%	24.00%
Al_2O_3 } Fe_2O_3 }	12.20	13.70	16.55	9.25	9.75
CaO	61.10	56.20	54.74	65.00	63.00
MgO	0.20	0.18	..	1.70	1.44
SO_3	0.24	0.21	0.27	0.51	2.12
Ign. loss	0.45	0.38	0.28	0.60	0.80
	99.29	99.83	100.22	99.51	99.11

tion of the silica due to poor mixing, (*b*) from an excess of silica in the batch due to poor propng. of the raw mats., (*c*) from an increase in the silica content of the clinker due to the incorporation of high silica ash from the fuel, and (*d*) in rare cases from inclusion of silica from the lining of the fur. (2) Excess of silica in powder over silica in the lump clinker, not sufficient to cause disintegration. (Analyses II.) Due to insufficient burning some bicalcium silicate is formed. (B) **Clinker totally reduced to powder**.—(1). Silica content of the batch too high, with the resulting formation of bicalcium silicate. (Analysis III.) (2) The compn. of the cement does not differ from other

known stable cements. The cause in this case was too much free sand in the batch, and insufficient burning to obtain tricalcium silicate. A sufficient quantity of Fe_2O_3 is often necessary to help the fusion. **Tests on Disintegrated clinker.**—If instead of allowing the clinker to cool in the air where it would disintegrate, it is thrown into cold water, the clinker remains intact. On drying and grinding the clinker, a cement is produced which when tempered with water has hydraulic properties. This would seem to indicate that there are two allotropic forms of the bicalcium silicate. The powder of bicalcium silicate resulting from the overburning of clinker has a grey-blue color, and a sp. gr. of 3.14 to 3.18. On adding the powder to cements and mortars, the increase in powder content from 10 to 50% (*a*) required increasing amts. of water for tempering the mixts., (*b*) delayed the time of initial and final set, and (*c*) decreased the crushing strength appreciably at each addition of powder. Cf. *Jour. Amer. Ceram. Soc.*, **4** [10], 874(1921). L. N.

White brick made from blast furnace slag. AUGUSTE LIEVIN. *Rev. Mat. Constr. Trav. Pub.*, **170,** 241–3(1923).—Slag from blast furnaces is run into water, where it breaks up into granular pieces. 30% of lime is added to the dried slag and the mixture pulverized in a tube ball mill. The resulting mass is then mixed with 10% lime and sufficient water to moisten it. The body is pressed into brick in a brick machine, with a capacity of 1000 brick per hour. After hardening for three months, the brick are ready for use. Six photographs are given of the plant at Pont-à-Mousson (France), where the slag is utilized for brick-making. L. N.

The setting of plaster. JOLIBOIS AND CHASSEVANT. *Comptes Rendus*, **177** [2], 113–116(1923).—At a temp. of 30° $CaSO_4$ calcined at 300° and below gives a supersatd. soln. of 7.3 g. per l. of anhyd. $CaSO_4$. The dihydrated $CaSO_4$ gives a satd. soln. of 2.1 g. per l. at 30°. The soln. reaches its limit of supersatn. in approx. 10 min. When calcined above 300° the max. soly. of $CaSO_4$ becomes a function of the temp. at which it was calcined. The setting of anhyd. $CaSO_4$ proceeds in 3 steps. (1) Formation of solid hemihydrate $CaSO_4{}^1/_2H_2O$. (2) Soln. of $CaSO_4{}^1/_2H_2O$. (3) Crystn. of gypsum. Cf. *Ceram. Abs.*, **2** [10], 214(1923). W. R. K.

Potash and waste heat recovery from cement kilns. ANON. *Chem. Age*, **9,** 442(1923).—Announcement has been made of a new method of effecting recovery of potash from dust of cement kilns (an English invention), which new process presents possibilities in the way of utilizing waste heat for steam-raising purposes. Expts. with this system have shown that with certain grades of raw mat. some of the dust from the kilns will collect in caked form on hot surfaces, and that this caked mat. contains potash salts and other ingredients which make it valuable; this caking mat. may be sold at a much higher price than the finished cement. The part of the dust adhering or caking to the hot surfaces has a different chem. compn. from the rest of the dust which will not so adhere, making possible the recovery of the valuable by-product. This caked mat. is removed from the walls by means of scrapers; from the primary collecting flue hot gases are led through a ht. absorbing device in the shape of a waste-ht. boiler. Here a considerable reduction in temp. of the gases is effected; their vol. and velocity are likewise reduced and separation of the remainder of the dust is facilitated. The inventor states that because of the cooling of the gases in this way the dry dust separators beyond the boiler have gases of less velocity to handle; moreover the washers through which the gases subsequently pass, operate much more satisfactorily on the cooled gases, as very hot gases tend to evap. and carry away the spray water in the form of steam, and interfere with the satisfactory opern. of the washer generally. Also the cooled gases are much more readily handled by the fan. In cases where the final removal of the dust is effected by elec. means, the reduction in temp. of the gases is of great advantage. O. P. R. O.

Dehydrating gypsum by steam under pressure. F. B. STUART AND C. A. RIVERO. *Chem. Age* (N. Y.), **31,** 476(1923).—The common practice has been to break up the rock gypsum and then ht. the fragments by means of an open fire to drive out the moist. This has been both wasteful and expensive. F. B. Stuart and C. A. Rivers of El Paso, Texas, have demonstrated that gypsum can be dehydrated by steam as shown in U. S. Pat. No. 1,463,913. By this method the rock gypsum is loaded into steel cars which are run into cylinders of 6 ft. diam. After bolting on the cylinder heads, steam is admitted to 150 lbs. pressure, where it is maintained for about 4 hrs., depending largely on the physical structure of the gypsum. At the expiration of this period the steam is shut off and after the pressure within the cylinder has been considerably reduced, the balance of the steam is blown off. Upon the removal of the car from the cylinder it will be found that the gypsum has been uniformly dehydrated. It is now ready to be crushed and pulverized. The material in this form is commercially known as plaster of Paris and is mixed with other substances in the manuf. of numerous forms of building material in which gypsum is a primary constituent. O. P. R. O.

A study of lime kilns. A. E. TRUESDELL. *Rock Products,* **26,** 9–15(1923); cf. *Ceram. Abs.,* **1** [9], 242(1922).—In a progressive series of articles, kilns, principles of combustion, dissociation of limestone, htg. chambers and fur., efficiency and econ. of kilns, control of kilns are discussed, and a general summary is made at end. In proper combustion amt. of excess air, draft, ht. losses, and manner of htg. must be considered. Cryst. stones which disintegrate under slight shocks while htg. must be burned in some manner which disturbs the stone less *e. g.,* in a pot kiln, or where motion can be controlled as in rotary kiln. Since lime is a poorer ht. conductor than stone, the smaller the lumps the less ht. required to dissociate entire lump, and the quicker it will take place. Approx. 1250°C is used for burning high Ca lime. The introduction of steam by various means assists the dissociation. The size and shape of htg. chamber should comform to best practice for the particular stone. Vertical kilns cannot burn soft or small stone. Hoffman or ring kilns will burn soft stone. Rotary kilns due to control burn various types including soft and small sized mat. All fuels are used, but a high calorific value fuel is not needed since temp. is not high. Radiation, poor combustion, excess air, too much draft, improper design of fur., lack of attention to charac. of different fuels are causes of ht. losses and trouble. The fixed charges for opern. of a lime plant must also be considered before deciding on equipment to be used as this has an appreciable effect on cost of burned product. Advantages and disadvantages of pot kiln, mixed feed kiln, vertical kiln, Hoffman or ring kiln, tunnel and rotary kiln are listed and briefly discussed. In any case local conditions as regards stone, fuel, power supply and market will also govern selection of kiln. C. R.

Plaster from limestone dust. C. F. WILLARD. *Rock Products,* **26,** No. 13, 39–42 (1923).—By reducing limestone to a colloidal state it is possible to make a hard plaster and thus eliminate the cycle of limeburning, hydrating and hardening. Incorporated solid colors are unaffected and plaster is waterproof. Walls thus finished can be polished with an agate burnisher and a surface like marble produced. It adheres to rough boards and can be used as a stucco material. Patents are applied for. H. C. P. (*C. A.*)

The influence of temperature on the disintegration of Portland cements due to the presence of gypsum. H. KÜHL AND H. ALBERT. *Zement,* **12,** 201–3, 210–13(1923).—Port. cements were mixed with 2, 10 and 20% gypsum. Test specimens were made of each. These were stored at temps. varying from 0° to 100°. The specimens with 2% gypsum showed some disintegration at the end of 28 days. Those with 10% gypsum disintegrated at the end of 14 days and those with 20% gypsum at the end of 7 days. The greatest disintegration occurred at 20–40°. At 100°, no disintegration occurred in any of the specimens. R. F. S. (*C. A.*)

Enamel

Records early stove industry. E. C. KREUTZBERG. *Foundry*, **51** [24], 973–80 (1923).—An historical acct. of stove manuf. in the U. S. in colonial days, with many photographs. M. E. M.

Tells of pearlitic cast iron. CARL SIPP. *Foundry*, **51** [24], 986–7(1923).—Pearlitic cast iron is a recent development in Germany. The author claims a high degree of flexibility, increased resist. to shock, high combined carbon without a high brinnell hardness, and great stability of structure at high temp. No details are given of the process of manuf., which is patented. M. E. M.

Glass

Natural sillimanite as a glass refractory material. S. ENGLISH. *Jour. Soc. Glass Tech.*, **7** [27], 248(1923).—An investigation as to the suitability of natural sillimanite as a glass making refrac. The foll. tests were carried out: Detn. of a suitable working mixture; meas. of the drying and firing contractions; detn. of the porosity after firing; meas. of the amt. of the corrosion by soda-lime and potash lead-oxide glasses; meas. of the reversible thermal expansion. For purposes of comparison similar meas. under identical conditions were made on a standard pot clay mixt. Natural sillimanite can be satisfactorily bonded so as to form slabs and small crucibles by the use of a comparatively small portion (9%) of ball clay. On drying this mixt. of sillimanite and clay shows a very small shrinkage and on burning to 1400° it has a negligibly small further contraction. The porosity of the fired sillimanite mixt. is rather less than that of a standard pot clay mixt. Sillimanite crucibles suffer very much less than do clay crucibles from the attack of glass at high temps. Up to 800° the coeff. of expansion of the sillimanite mixt. after burning at 1400° is quite regular and has a value very close to the mean coeff. of expansion of a hard burned standard clay mixt. Natural sillimanite should serve as an excellent basis for glass-making refrac., chiefly on account of its high m. p., its very low drying and firing shrinkages and its marked resistance to corrosion by molten glass. J. G. P.

The corrosion of fire clay by alkali-lead oxide glasses. EDITH M. FIRTH, DONALD TURNER AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **7** [27], 218(1923).—Expts. were made in small exptl. pots on the corrosive action of soda and potash-lead oxide batches on different fire clays at a temp. of 1350°, the amt. of corrosion being measd. by the amt. of alumina and iron oxide abstracted from the fire clay during the melting process. The results showed that: Different fire clays resist the action of melted batch to different extents. High alumina content alone does not bestow resistance to corrosion on a fire clay nor alone does low porosity. Of 4 clays tested the least corroded and the most corroded both had a high alumina content and low porosity. Potash glasses are not less corrosive than soda glasses of equivalent alkali content. In our expts. they were found to be somewhat more corrosive. The corrosion of fire clay refrac. mats. occurs most actively during the melting opern. the attack by the glass itself being very much slower than that due to the batch constituents, especially the alkali salts. It was proved that maintaining a pot at a temp. of 1350° for a period prior to charging in batch increased its resistance materially to attack. Firing for 24 hrs. gave much better results than 3 hrs. Spraying the interior of the pot with a little soda ash and htg. it for 3 hrs. at 1350° was not found to possess any advantage in diminishing corrosion. Thorough batch mixing and rapid melting should conduce to diminish the corrosion of fire clay glass batches. J. G. P.

Some observations on the corrosion of fire clay materials by alkali salts. DONALD TURNER AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **7** [27], 207(1923).—Mixts.

of well burnt fire clay grog with a particular alkali salt were htd. together in a crucible of non-corrodible mat., and detns. of the corrosive action were made. Methods given. Sodium carbonate, potassium carbonate, sodium nitrate, potassium nitrate and borax all attack well-burnt fire clay extensively even at as low a temp. as 800°. The nitrates are more corrosive than the carbonates, and the potassium salts more active than the sodium salts. Sodium sulphate at 800° has only a very slight action on burnt clay as compared with the carbonate and nitrate. Rise of temp. between 800° and 900° causes a rapid increase in the rate of corrosion due to carbonates and nitrates. Different clays, fired at the same temp., exercise different degrees of resistance to corrosion by alkali salts. The resistance is not dependent directly on the chem. compn. One aluminous clay was most attacked while a second was least attacked of 4 clays tested. The corrosion probably depends on the density of the clay body. Fire clay burnt at 1400° is more resistant to corrosion than when burnt only at 1300°. J. G. P.

The effect of saltcake in soda-lime batches in corroding fire clay refractory materials. EDITH M. FIRTH, F. W. HODKIN AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **7** [27], (1923).—A series of glass batches was prepd. in which the soda ash was gradually replaced by its equivalent of salt cake and from them glasses were melted. Meltings were made in small crucibles and were made in triplicate, the 3 pots being set in the same fur. so as to insure, as far as possible, similarity of fur. conditions. Melts were made to definite temps. and for definite time intervals and an analysis of each sample of glass was made to det. from the increase in the amt. of alumina and iron oxide the extensiveness of corrosion. Results are given and a discussion. J. G. P.

Ionization in glass. Ionization by collision in glass at high field strength. A. GUNTHER-SCHULZE. *Physik. Z.*, **24,** 212-3(1923).—The sp. condy. of glass at high elec. field strength can be compared to the same phenomenon in gases. Log α = abX, α being the measd. condy. and X, the field strength. W. M. C.

Notes on the Ashley bottle machine. S. ENGLISH. *Pottery Gaz.*, **48,** 1299(1923).—History of development of Ashley bottle machine. J. W. H.

The effect of titania on the properties of glasses. W. E. S. TURNER AND A. R. SHEEN. *Pottery Gaz.*, **48,** 1804-8(1923).—Titania renders annealing of glasses easier and hinders the devitrification. If titania glasses are ht.-resisting as all available literature indicates, this property is not due to a low thermal expansion, hence further tests are necessary to det. accurately why titania glasses are ht. resisting. J. W. H.

Italian laboratory glass industry. ANON. *Chem. Trade Jour. & Chem. Eng.*, **73,** 459(1923).—The war is responsible for the lab. glass indus. in Italy, which has grown to such propns. that it now supplies the home market completely and also exports neutral glass tubes to Spain, France and Belgium. The quality of the products has secured a reputation even in competition with the world famous products of Jena. O. P. R. O.

Automatic manufacture of glass bottles. ALEXANDER FERGUSON. *Chem. Trade Jour. & Chem. Eng.*, **73,** 393(1923).—F. gives a description of the new automatic mach. for mass production of glass bottles, for which he has prepd. designs. It is called the cyclone fur., and it is said that it allows 540 T. of glass to be made in 168 hrs. per week, or 120 bottles per min. Ordinary tanks usually require 100 T. of coal to 100 T. of glass, while it is possible, with the cyclone fur., to use only 30% coal to glass, with a safety margin of $13^1/_2$ T. in each 100 T. glass in a fur. occupying 600 sq. ft. instead of the present 8800 sq. ft., and yet leaving the ground area clear for any other purpose. It is claimed to be also entirely automatic, requiring no skilled labor after the chemist has settled the batches for the glass required. The principal feature of the fur. is that the burners are so set as to give a whirling motion to the gases, which travel about 175 ft. per sec. The walls of the fur. are inclined from top to bottom and the batch mat. is ground to a mesh of about 60. Into these whirling gases the batch mat. is fed, and the description

of the opern. is that the molecules of glass, once formed, are cast forth from the whirling gases and coalesce into a liquid homogeneous paste and flow down the walls of the fur. like glucose under the influence of radiant heat. The glass passes on to the forehearth, from which it is gathered and delivered to the bottle-forming plant. The next portion of the app. is that in which the molten glass is sucked up automatically and transferred to the molds, which are mounted on the periphery of a large wheel. These rotating gatherers are so arranged as to suck up the desired quantity for the particular size bottle. The cyclone machines occupy only 1/8 the area of the Owen's gatherer with 3 times the capacity, although the times in the molds are identical. The total outlay on the machine and on operation is much less than in ordinary practice. So far it is just in the exptl. stage, but the demonstration given has been satisfactory. O. P. R. O.

Glass manufacture. ANON. *S. African Jour. Indus.*, **6**, 146(1923).—Glass manuf. on larger scale is needed for the Union of S. A. At the present time the Union is importing glass bottles and jars at the rate of some £115,000 per annum. Inquiries into the raw mats. have, so far, left no doubt that everything requisite for the making of, at least, common glass suitable for bottles and jars for commercial purposes is obtainable in S. A., and it is believed by competent judges that the whole of this oversea expenditure could be avoided by local glass manuf., and further that a surplus could be provided for an export trade. O. P. R. O.

The geology of glass sands. H. E. ELKINGTON. *Rock Products*, **26** [19], 28 (1923).—The origin of the 4 large glass sand producing regions of the U. S. are discussed briefly. N. J. sand is a refuse sand, with rounded grains, and usually contaminated with ilmanite, rutile, brookite. Pa. sand of the Oriskany region has been consolidated on deposition by ht. and press. and a sandstone of great firmness has been formed. The grains are sharp, and free from the contaminating subs. of the Jersey sands. Ill. glass sand is rounded, and of great purity, being laid down in St. Peter's period of the Ordovician age, and then sorted afterwards by wind and water. The Mo. deposits are similar to the Ill. deposits though smaller. C. R.

Initial heat leers. W. S. MAYERS. *Glass Ind.*, **4**, 163–6(1923).—In the initial heat leer the ware is introduced immediately after being pressed while still luminously hot, and becomes uniformly heated by internal conduction. Very little outside ht. is necessary as only the pans of the leer need be heated. The ware passes through a tunnel heavily insulated against heat loss, and cools gradually as usual. These leers require only about 1/6 the pan area required by an ordinary leer of the same production. See *Ceram. Abs.*, **2** [5], 96(1923). D. E. S.

Electrification of the Allegheny Plate Glass Company. G. P. WILSON. *Glass Ind.*, **4**, 127–9, 152–3, 169–72(1923); (Reprinted from *Elec. Jour.*, **20**, April(1923)).—This article is a description of the process of making plate glass at Glassmere, and is illusd. with cuts of elec. controls, layout diagrams, etc. The whole plant is operated by elec. power. D. E. S.

Furnace and combustion calculations. H. S. BRADY. *Glass Ind.*, **4**, 148–52 (1923).—Calculations are given of draft pressure, ht. regeneration, theoretical flame temp. and air required for complete combustion. D. E. S.

Tensile strength of glass. J. T. LITTLETON. *Phys. Rev.* (1923).—Lack of uniformity and reliability in the results hitherto obtained is due to the fact that the strength of the surface is greatly reduced by slight scratches. *The new method of measurement* here described, attempts to eliminate as far as possible the effect of surface defects. A bar of glass is used which has been cut from the middle of a slab which had been heat treated in such a way as to leave the upper and lower surfaces of the bar under high compression, while the inside is under tension. When this bar is broken by bending, the tension introduced in the lower surface is largely neutralized by the initial compres-

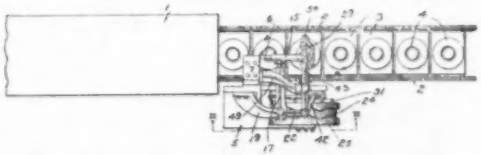
sion, so that the maximum tension is not in the lower surface but in a zone nearer the neutral axis. The initial stresses are measured by means of polarized sodium light and a calibrated Babinet compensator, and these combined graphically with the stress due to the central load required to break the bar, give the maximum tension introduced which is taken as the lower limit to the strength of the glass. In this way values of 12 and 15 kg./mm.^{2} were obtained for a lead glass and a borosilicate glass, values twice as great as those given by the usual methods; and the mean deviation of individual measurements is less than half as great. J. T. L., JR.

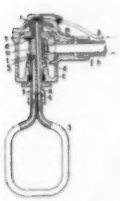
The wetting of glasses by mercury. EARLE E. SCHUMACHER. *Jour. Amer. Chem. Soc.*, **45**, 2255–61(1923).—Hg was placed in containers whose walls were as free as possible from adsorbed gas. Wetting was generally obtained on containers of quartz but only occasionally on pyrex or soda-lime glass. The difficulty of removing adsorbed gas increases with the alk. content of the glass and the tendency toward wetting with Hg decreases. This latter may be due to the adsorbed gas or to formation of a surface film of NaOH and amorph. SiO_2. D. E. S.

Polishing glass with acid. O. PARKERT. *Diamant*, **45**, 165, 177(1923); cf. *Ceram. Abs.*, **2** [6], 166(1923).—The ware is first washed in a bath of H_2O 1000, H_2SO_4 12, and HCl 1. It is then dipped for about 45 sec. in a soln. of H_2O 1, H_2SO_4 2, and HF 1, preferably kept at a temp. of 40–50°. J. B. P. (*C. A.*)

PATENTS

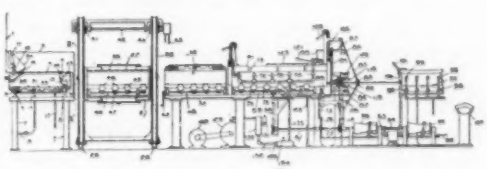
Glassworking machine. THEODORE H. SLOAN. U. S. 1,478,261, Dec. 18. In a glass-finishing app., the combination of a conveyor for carrying glass articles through a htg. fur., a frame, a tool carrier mounted on the frame for reciprocating movements parallel to the conveyor, a finishing tool mounted for reciprocating movement on said carrier, an article positioner borne by the carrier and movable to and from an article in coördination with the reciprocation of the tool, and connections coördinated with the movement of said conveyor for reciprocating said carrier on the frame and said tool in the carrier.





Means for stirring glass. CHARLES ALGERNON PARSONS. U. S. 1,479,511, Jan. 1. For use in the manuf. of glass, a stirrer with means for giving thereto a rotary motion about its own axis and an orbital movement, substantially as and for the purposes described.

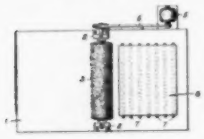
Glass manufacture. ROBERT M. CORL. U. S. 1,478,554, Dec. 25. In combination means for advancing a set mass of glass, means for applying a converting ht. to the forward end portion of the mass to flow therefrom a sheet of lesser thickness than the mass, means for carrying away the sheet as it flows from the mass, means acted on by the sheet to regulate the htg. means to maintain a substantially uniform flow of glass from the mass, and means for supplying glass to the rear end of the mass to maintain its continuity and the continuity of flow of glass therefrom.



Etching compound. AARON M. HAGEMAN and JULIUS M. KOVACHY. U. S.

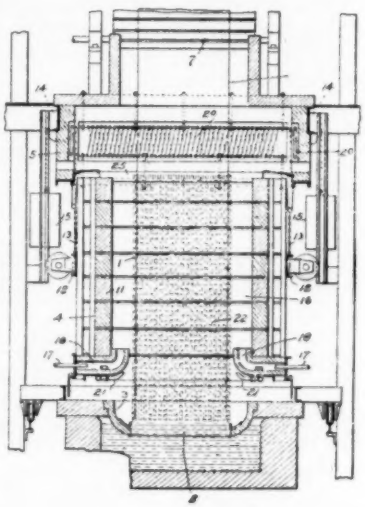
1,471,466, Oct. 23. A compound suitable for etching glass having, as its active ingredient, a harmless acid salt.

Process of polishing glass. CHRISTOPHER BROWN. U. S. 1,480,542, Jan. 15.

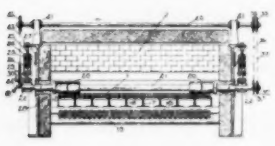


A process of smoothing or polishing a glass sheet which consists in rotating a brush with its axis extending transversely of the sheet and having radially extending fibers with the ends of such fibers in contact with the sheet at a high rate of speed so that the fibers engage the sheet with an impact or whipping action, and supplying an abrading or polishing material to make such action effective to smooth or polish the glass.

Apparatus for drawing sheet glass. ROBERT A. MILLER. U. S. 1,480,625, Jan. 15. An app. for drawing sheet glass from a bath of molten glass, means for drawing a sheet upwardly from the bath, temp. equalizing means in the form of a flexible openwork curtain surrounding the sheet and extending upwardly from the bath, a leer casing surrounding the curtain, and means for applying heat to the interior of the casing.



Apparatus for drawing sheet glass. OTTO C. MILLER. U. S. 1,481,218, Jan. 15. In a machine for drawing sheet glass, a source of molten glass, and means for drawing a sheet of glass therefrom, comprising an endless carrier and flattening table for the sheet, means for driving the carrier, a plurality of cross-shafts above the sheet and table, asbestos rollers carried by the shafts engaging the edge portions only of the sheet, means at either end of the shafts for yieldingly supporting a portion of the weight thereof, means for driving the shafts in unison, and means for internally cooling the shafts and rollers.



Heavy Clay Products

Improvements in drying refractories or other goods. J. HOLLAND AND W. J. GARDNER. *Pottery Gaz.*, **48,** 1799–1801(1923).—See *Ceram. Abs.*, **3** [1], 18(1924). J. W. H.

Up-to-date methods of manufacturing sewer pipe. STAFF ARTICLE. *The Clayworker*, **80,** 30–1(1923).—Article deals with the mfg. process of sewer pipe in the following steps: mining, prepn., molding, drying, setting, firing and glazing. J. W. H.

Grinding and screening clays. J. H. KRUSON. *Brick and Clay Rec.*, **63,** 691–4 (1923).—Water content and size of clay lump has considerable bearing upon the clay prepn. Experience has shown that weathering and preliminary grinding often improves the product and reduces repair costs. Author gives helpful suggestions on prepg. clays and shales, such as proper speed of pan, wt. of mullers, etc. J. W. H.

Essential qualifications of brick pavers. ANON. *Brit. Clayworker*, **32,** 195–200 (1923).—The quality of paving brick was investigated by the Brit. Paving Brick Assoc. by means of rattler tests. Tests were made both of the dry brick and upon the wet

brick. In testing granite block in this manner it was found that the wear on the wet block was about four times as great as that on the dry block. In the case of paving brick, however, it was found that the wet brick tested 10% less in one case. In two other cases the wear was increased $12^1/_4$ and $16^1/_2$%. This proved the important fact that paving brick may be far superior to granite block when wet. This may explain the fact that brick roads are declared to be cleaner than any others, and why they outlast other paving materials. Contrary to what was expected, a brick which had been made by the semi dry process passed as a No. 1 paver and showed less wear when wet than when dry by 10%. It also wears more uniformly than brick made by the stiff mud or soft mud processes. This brick had an absorption of 2.67%. Structure defects revealed by the rattler tests are as follows: laminations, too granular a condition of the substance, softer condition of the interior of the material than the outside, brittleness, and weakness of the stiff mud brick where the clay escape is situated. These defects were found in brick which stood the test as well as in those which failed, so that these are no safe criterion in ascertaining whether a brick will stand the test or not. It was found that brick when repressed were not improved. The brick lose about as much in the first 450 rev. as they do in the subsequent 1350 rev. as is shown below:

First 450 rev.	Total of 1800 rev.	Times
7.8	17.8	2.28
6.6	17.9	2.71
10.6	26.6	2.51
10.8	25.7	2.38
12.0	31.8	2.65
12.7	33.8	2.65
13.3	35.8	2.70
17.5	46.1	2.63

H. G. S.

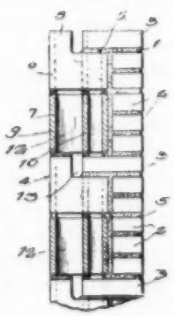
Bricks from oil-shale. ANON. *S. African Jour. Indus.*, **6**, 324(1923).—Extensive deposits of oil-shale are found in Germany but, owing to their small oil-content, their development presents many difficulties. A method has recently been proposed for utilizing these shales to make a cheap building material; the shale is ground and mixed with sand or clay, the proportion depending on the richness of the shale. Bricks of this mat. are shaped and placed in a kiln. where they are baked by the combustion of their own oil. The bricks so obtained contain only small quantities of calcium sulphate and sulphite, and are as hard as ordinary bricks, from which they differ little in appearance. O. P. R. O.

Heat economy in sand-lime brick plants. ANON. *Arch. Wärmewirtschaft*, **4**, 96–100(1923).—Details are given of the distribution of the heat used in 2 plants; the fuel consumption could be reduced $^1/_3$ by proper equipment.

E. W. T. (*C. A.*)

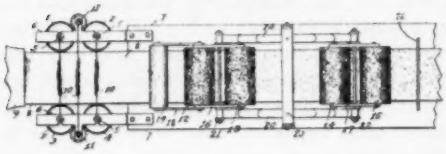
PATENTS

Composite brick and tile wall construction. WILLIAM GUSTAVUS DEMAREST. U. S. 1,479,379, Jan. 1. A composite brick and tile wall construction comprising, in combination with a brick facing having ordinary courses and header courses, a plurality of complementary courses of tile arranged behind each group of ordinary courses comprehended between adjacent header courses, certain of the tile having reduced extensions disposed behind said header courses, the tile and the reduced extensions having continuous vertical openings therein constituting suitable vertical



air passages through the wall and serving to dissipate the moisture finding its way in through the wall.

Process for surfacing clay products. EMMETT V. POSTON. U. S. 1,477,663, Dec. 18. A process of surfacing plastic substances consisting in passing the plastic bar between a series of press. rolls having granular surfaces of varied degree of coarseness, and subsequently severing the substance into building elements.



Refractories

How to make good silica brick. E. E. AYARS. *Brick and Clay Rec.*, **63**, 550 (1923).—A. discusses each step in detail, beginning with the selection of the raw mat. and following it to the final inspection. Hard quartzite coming from either the floe or ledge and containing 97–98% silica produces a strong brick of high refractoriness. Only sufficient raw mat. should be stored at the plant to insure a steady supply; any advantages gained by additional amounts is lost because of the increased overhead. Gyratory crushers are favored over the swinging jaw type. Finer crushing is suggested; it may increase production, lessen the wear on the grinding pans, or permit the use of lighter equipment. Underdriven pans with wearing parts of 2% manganese steel are recommended. The batch usually contains 8–40% of bats, 20% being very common. 5% of sand is sometimes added to reduce plasticity. The dry process of grinding is mentioned as a means of obtaining a more uniform grind but more careful standardization of the wet process and the use of ammeter charts is favored. A coarse grind is used to withstand the fluctuating temp. of the open hearth; finer grinds give better workmanship and a tougher brick for use in coke ovens. European manufacturers add 25% of impalpable powder (200 mesh) in order to obtain more rapid conversion to tridymite. Fresh lump, hydrated, or air-slaked lime all give a satisfactory bond. The details of lime slaking, mud storage, distribution, and brick molding are discussed. The molder can only be held for poor slicking and spongy corners. Rusting of pallets discolors brick; it may be overcome by painting with cheap cylinder oil or using enameled pallets. Vent bottom molds are used for small shapes, slip liner molds for large ones. In Germany 600–2500 small shapes are made per hour on the hydraulic press, under a pressure of 4000 lbs. per square inch. Amer. toggle presses are not very successful as they exert a press. of only 1000 lbs. per sq. in., whereas at least 1500 lbs. is necessary. Proctor driers are satisfactory for drying standard brick in 24 hrs. Tunnel driers operating at 200–325°F give good results in forty-eight hours; the lower temps. and longer time give least breakage. Brick entering the driers semi-dry give more trouble than those freshly made. Waste-heat driers are difficult to operate. Hot floors are very good especially for shapes; they are flexible and the product is strong. Good ventilation above the floor and exhaust pipes below are necessary to prevent condensation. Kiln construction is discussed. A 32′ kiln with a 19-day turnover is favored over a 40′ kiln with a 26-day turnover. Emphasizes regular cleaning of flues, flexible flash walls, and thick wickets. Under setting he gives details of foundation, benches, protection from flame, hot spots, allowance for expansion, and reduction of breakage. In heating up he advises a temp. increase of 33°F per hour up to 1500°F; at higher temp. less care is necessary. High volatile coal, slightly clinkering, low in sulphur, 14,000 B.t.u., is recommended. 1.6 T. per M. is mentioned as being necessary with round down-draft kilns to cone 18, 2.0 T. per M. to cone 20. Smaller amounts are used in Europe by burning to cone 15 in a Hoffman kiln. Cold spots are due to poor draft. He attributes 90% of breakage to rough handling, imperfect molding and drying.

10% to burning. This paper is original and of particular value in that it attacks the problem from the practical mfg. standpoint. R. M. H.

Carbonization of clays. W. SMITH. *Min. and Met.*, **4**, 606(1923).—Abstr. of paper before Refrac. Mat. Sec. of Ceramic Soc. of England. S. shows that by satg. clay, at a certain stage of heating, with hydrocarbon gases or volatile hydrocarbons under press., the gases dissociate and deposit very finely divided carbon on the particles of clay. This occurs during the "biscuit" period when the clay has max. porosity and before firing contraction has set in. The clay thus carbonized is black and when contraction takes place during heating in the final stages of firing, great pressure is exerted on the enclosed particles of carbon and a dense, hard, composite body is formed. By firing in a strongly oxidizing flame this product may be converted into a microscopically porous structure, owing to burning away of the carbon, the refrac. properties being highly increased. For the black carbonized clay the term "carbonite" is suggested for indus. purposes. It is best adapted for abrasives, mixing with cement, roadmaking, etc.; it is refrac. to heat in absence of air and resistant to acids, as well as impervious to atmospheric action. For the white clay, from which the carbon has been burned out, the term "carbo-calcined" clay is suggested. Its refrac. properties are due to the artificially produced porosity and it usually does not melt at anywhere near the same temp. as the original mat. The durability of carbonized brick in indus. fur. is much greater than that of bricks made of untreated clay. Binding is accomplished by pressure, as with magnesite. Artificial binders should be used sparingly and with carbo-calcined mats. the binder should preferably be of the same compn. as the original clay. Carbonization increases the normal function of sillimanite. By special treatment of certain clays, the production of a brick, retort, and crucible consisting mostly of sillimanite has been accomplished on a small scale. Bricks of carbonized clay possess refractoriness and hardness and exhibit little or no contraction or expansion. See also *Ceram. Abs.*, **2** [8], 182(1923). R. J. A.

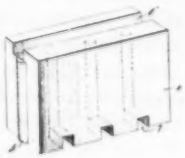
Bauxite cements (Ciments fondus). GABRIEL PATROUILLEAU. *Le Ciment*, **28**, 259–60(1923).—It is suggested that the bauxite cement of av. percentage compn. SiO_2 12, Al_2O_3 44, CaO 44, with a corresponding mol. compn. 1 SiO_2, 2 Al_2O_3, 4 CaO is a very basic oxysilico-aluminate of lime, which may be written SiO_2, Al_2O_3, CaO + mAl_2O_3 + nCaO. L. N.

Refractories in the steel industry. J. S. MCDOWELL. *Blast Fur. & Steel Plant*, **11** [11], 569(1923).—The phys. and chem. properties of the refrac. used in the blast fur. and steel indus. are listed and discussed, together with some notes on their requirements for use in various parts of different types of fur. employed in the indus. C. R.

Appalachian bauxite deposits. W. A. NELSON. *Bull. Geol. Soc. Am.*, **34**, 525–39 (1923).—Upon boiling bentonite, formed from altered volcanic ash, with H_2SO_4, practically all of the Al_2O_3 goes into soln. Treatment with tannic acid will then cause the Al_2O_3 to ppt. These expts., it is claimed, show "that the bentonite may very readily be the source of the Al_2O_3 in the bauxite deposits of the Appalachian region." W. F. H. (*C. A.*)

PATENTS

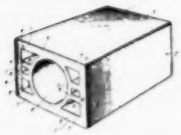
Refractory composition. JOHN L. OHMAN. U. S. 1,479,107, Jan. 1. A refrac. compn. for ht. resisting articles, comprising silicon carbide and fused silicon oxide, and cryst. graphite. See also *Ceram. Abs.*, **2** [10], 226(1923).



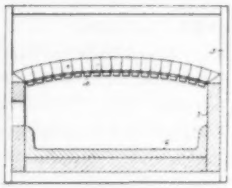
Baffle brick. FRANK H. WAITE. U. S. 1,478,309, Dec. 18. In a device of the class described, a brick comprising a rectangular body having a longitudinally extending channel in one longitudinal face thereof and a transverse channel in its opposite

face, and an internal conduit connecting said channels. See also *Ceram. Abs.*, **3** [1], 15(1924).

Building tile. WILLIAM J. GILBERT. U. S. 1,477,258, Dec. 11. A building tile of the character described comprising rectangular outer wall portions, and inner web portion connected with said outer wall portions, all said inner web portions being thinner than any of said outer wall portions, said webs being arranged so as to provide a large central opening, and smaller side openings, said side openings comprising larger corner openings and smaller intermediate openings.

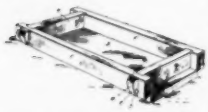


Process for manufacturing new and improved high refractory. CHARLES JAMES CRAWFORD. U. S. 1,477,810, Dec. 18. A silica brick consisting of tridymite bonded with a clay of high alumina content. The herein described method of mfg. a fixed volume high refrac. substance which consists of burning a silica material in a kiln the atmosphere of which is charged with a gaseous catalyzer formed independently of the material being treated.

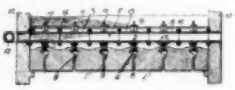


Metallurgical-furnace roof. CHARLES JAMES CRAWFORD. U. S. 1,477,811, Dec. 18. A fur. roof of refrac. material of staggered checker work construction.

Fire-brick mold. ROBERT L. KINTON and AMOS F. HIBNER. U. S. 1,478,746, Dec. 25. A mold comprising a bottom and encompassing walls and entirely open at its top to permit of unrestricted discharge of the molded product when the mold is completely inverted, the mold being provided upon one of its said walls with spaced rockers to engage a surface upon which the mold is to be overturned, the said rockers having accurate tread surfaces, the tread surface of each rocker, at one end, terminating substantially at the normally lower edge of the wall upon which the rocker is provided and at its other end merging substantially with the normally upper edge of said wall, the said tread surface of the rocker throughout its length describing a substantially cycloidal curve the higher portion of which is nearer the open top than the bottom of the mold.



Fire arch. HERMAN A. POPPENHUSEN. U. S. 1,477,895, Dec. 18. In a fire arch a plurality of laterally spaced beams, a plurality of rows of tiles, one row in each of the spaces between said beams and suspended therefrom, a plurality of conduits above said beams and adapted to have a cooling medium circulated therethrough, said conduits extending across said beams, and means carried by said conduits and engaging said beams for suspending the same from said conduits.



Whiteware

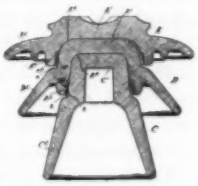
Production of porcelain for electrical insulation. F. H. RIDDLE. *Jour. Am. Inst. Elec. Eng.*, **42**, 988–94(1923); cf. *Ceram. Abs.*, **3** [2], 49(1924).—Deals with the firing of elec. porcelain. Methods of measuring temp.—thermocouples, pyrometric cones and shrinkage bars—are described, and the defects of periodic kilns dwelt on, these being chiefly loss by radiation and lack of recuperation and irregularity of draft which causes non-uniform temps. among saggers. A full description of the muffled tunnel kiln (Dressler) is given, with photographs of loading platform, entrance end and combustion chambers, together with a diagram of cross-section through the hot zone and a typical time-temp. record. In addition to economy of fuel, which may mean a saving of as much as 80% over the amount used in periodic kilns of equal output, the tunnel kiln

offers other advantages such as continuity of operation, slower deterioration of the brickwork, uniformity of ht. treatment and ease of loading and unloading. In discussing the mechanism of Dressler kiln, emphasis is laid on the need of maintaining very low draft velocity, both as regards air for combustion and the waste gases, and the equalization of temps. in the hot zone by convection, which is made possible by the circulation of air in the hollow carborundum chambers. The article is, on the whole, a distinct contribution to the physics of the tunnel kiln. A. F. G.

PATENTS

Improvements in refining clay, especially china clay. English Pat. 184,880. *Chem. Age*, China Clay Trade Rev. Sec., **15,** (1923).—Kaolin residues are treated with 86 pts. water contg. 1 pt. of potash water glass in soln., for 5 to 10 min. in a colloid mill and then allowed to stand for $^1/_2$ to 1 hr. in a tall vessel. In this time the whole of the silicates have been pptd. and particularly pure kaolin is present in fine suspension which is so fine that it shows Brownian movement in the ultra microscope and remains suspended for a long time. This was not to be foreseen since it was known that the above kaolin residues are at present considered waste products which have to be thrown away. The above process, however, allows of the recovery of as much as 40% kaolin, and more, while the silicates which are simultaneously obtained are also of high value. O. P. R. O.

Improvements in or relating to manufacturing of china clay. ANON. English Pat. 188,010. *Chem. Age*, China Clay Trade Rev. Sec., **9,** 15(1923).—A method of mfg. china clay according to which clay of large water content is pptd. as by settlement in a tank, centrifugal sepn. or the like, and the sepd. water is removed until a desired av. consistency is reached, after which the densest clay is removed from the pptd. layer, say, by suitable conveyor or other detaching means, without removal of the wetter portion, and the drying of said denser clay to any desired degree is completed upon a surface htd. by compressed evolved vapor. A drier is continuously supplied with clay of the desired uniform consistency, say by the combined opern. in sequence of a plurality of settling tanks, having mech. removal devices, centrifugal sepg. means or the like. The clay is refined by carrying it as a fine powder in a moving gaseous medium from which it is deposited in a selected condition. O. P. R. O.



Insulator. BENTLEY A. PLIMPTON. U. S. 1,478,912, Dec. 25. An insulator comprising a plurality of nested hollow sections having closed ends, the outer surface of the sides and end of the inner section fitting closely against and contacting with the inner surfaces of the sides and end of the outer section, one of the sections having a recess formed in its side opposite the adjacent surface of the coöperating section, and a cementing medium in said recess.

Equipment and Apparatus

A cheap electric resistance furnace of the tube type. H. FORESTIER. *Bull. Soc. Chim.*, **33,** 999–1000(1923).—A tube type fur. which is capable of htg. to 1000° in 30 min. and drops to 100° in $1^1/_2$ hrs. after turning off current is described. Around a metallic tube (3–4 cm. diam. for example) is wrapped a piece of paper. Over this is wound the resist ($3^1/_2$–4 m. of nichrome wire $^1/_2$ mm. diam.). The resist. winding is covered with a thin coat of alundum 1 to 2 mm. thick. This is htd. several min. in an oven. When dry the tube is placed vertically in a cylinder of asbestos paper and the space between filled with rapid setting cement. It is dried in the air some hrs. and then covered with asbestos insulation 3 to 4 cm. thick. It is then heated by passing a current through the resist. This chars the paper and allows the metallic tube to be

pulled out. Under the writer's conditions using 110 v., 4.5 amp. or about $^1/_2$ kw. were consumed. W. R. K.

The standardization of commercial viscosimeters. MADISON L. SHEELY. *Jour. Indus. Eng. Chem.*, **15** [11], 1104(1923).—The need of the standardization of viscosimeters and the advisability of expressing results in abs. units, is discussed. Method of calibrating and set up and operation of a typical glass outflow type of viscosimeter is given, with comparisons of various similar types. Calibration of the MacMichael, or torsional viscosimeter for a single range of viscosity is given and comparison with other types made. Results on the MacMichael viscosimeter indicate uniformly higher viscosities than obtained with out-flow types of colloidal solns. The suggestion is made that the lower velocities in the former have less effect in breaking down the colloidal aggregate, or cause a difference in rate of shear, resulting in apparent discrepancies in the absolute viscosity detn. with the 2 types. Results on true solns. compare quite well in both types of app., which lends force to the suggestion. A brief discussion of solns. suitable for use in calibrating viscosimeters is given. In general, non-volatile oils are recommended for this purpose for comparatively high viscosities.

R. D. L.

Notes on the Proctor drier. A. H. MIDDLETON. *Brit. Clayworker*, **32**, 226–31 (1923); Also *Pottery Gaz.*, **48**, 1803–4(1923).—For abstract see *Ceram. Abs.*, **3** [1], 19 (1924). R. D. L.

A new air preheater. F. S. N. HEWARD. *Combustion*, **9** [5], 393(1923).—Heat is carried in a mech. way to air for combustion. A fan draws fresh air into the upper portion of a casing which is divided in two parts by a vertical partition. The air is confined to one side of the partition, passing downwards to a similar semi-circ. chamber through a porous drum or rotor, and then to fur. Hot flue gases pass in opposite direction through rotor in second chamber, and to stack. Rotor transfers ht., and moves about 6 r.p.m., being made of thin sheet steel, and divided into sectors by radial plates. Ease of cleaning, no serious effect due to deposition of soot and tarry matter, and liberal htg. surface with very little obstruction to passage of air and gases in comparatively small dimensions pointed out. C. R.

Induction furnaces for non-ferrous metals. EMILE DEMENGE. *Rev. métal.*, **20**, 448–52(1923).—After a brief outline of the merits of induction furnaces, D. described in detail a furnace used by the Compagnie Française des Métaux which can effect continuous or variable agitation of the molten metal, allows of decanting clean metal, reduces oxidation and radiation losses to a min., and can be connected directly and simultaneously to the 3 phases of an ordinary circuit with an acceptable load factor. Also in *J. four élec.*, **32** 53–5(1923). A. P.-C. (*C. A.*)

Constant-temperature regulator for electric furnaces. JEAN SOLARI. *Bull. soc. chim.*, **33**, 1000–4(1923).—A device is described for maintaining const. within $\pm 5°$ (at 575°) the temp. of a resistance furnace. The regulator is a differential air thermometer actuating a Hg column which connects or cuts out added resistance in series with the main furnace. An auxiliary furnace in series with the furnace to be regulated contains the hot bulb of the differential thermometer. The main furnace is thus entirely free of obstructions. The auxiliary furnace has little thermal lag, thus causing the regulator to respond promptly to variations in the furnace current.

L. J. (*C. A.*)

A simple method of optical pyrometer calibration. FR. PATZELT. *Z. Physik*, **15**, 409–12(1923).—The positive crater of the carbon arc, like various standard combustion lamps, can be used as a standard of luminous intensity and therefore, with optical pyrometers, of effective temp. To this end it is necessary that the carbon should be of definite purity, and the current between 0.2 and 0.5 amp./mm.^{2} A very pure carbon is

naturally best. A pure carbon (mark "A" of Gebrüder Siemens & Co., 6 mm. in diam., with 15 amps.) gives a "black temp." of 3780°K. Errors may come from inaccurate optical arrangements, from impurity, and from the photometric adjustment.

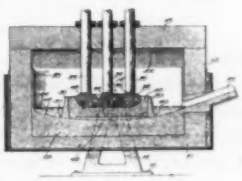
W. P. W. (*C. A.*)

A new centrifugal for separating solids from liquids. C. R. PLATZMANN. *Chem.-Ztg.*, **47**, 167–8(1923).—A description, with 5 cuts, of the app. of the Centrifugal Separators, Ltd., London, which combines features of the centrifugal and filter-press. The advantages of the app. are: low 1st cost, low operating cost, can handle suspensions for which presses are not suitable, independent of temps., small floor space, and the sepn. of the solids according to size of grain.

J. H. M. (*C. A.*)

PATENTS

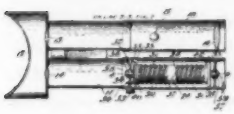
Electric melting furnace. ALFRED W. GREGG. U. S. 1,477,821, Dec. 18. In a device of the class described, a fur. chamber inclosing a hearth, sloping continuously downward from the side walls of the chamber towards its center, a central island in the hearth, and means for creating an elec. arc on the island without passing elec. current through material to be melted on the hearth. See also *Ceram. Abs.*, **2** [7], 166(1923).



Means for producing a sooty vapor in electric furnaces. GEORGE M. LITTLE. U. S. 1,477,372, Dec. 11.—An elec. fur. comprising a plurality of walls enclosing a fur. chamber, a carbonaceous resistor located in said chamber, a plurality of feed-pipes entering said chamber and a single means for permitting a fluid sooty-vapor-producing agent to enter said chamber through one pipe and a fluid oxidizing agent through the other pipe.

Electric resistance furnace. GEORGE M. LITTLE. U. S. 1,479,143, Jan. 1. In an elec.-resistance fur., in combination, a plurality of refrac. walls inclosing a fur. chamber, a plurality of refrac. muffle tubes extending through said chamber, and a relatively narrow, elongated refrac. resistor member located in the chamber below said muffle tubes and extending transversely thereof, thereby obtaining a predetd. temp. gradient from the intermediate portion of said muffle tubes to the ends thereof. See also *Ceram. Abs.*, **2** [9], 205(1923).

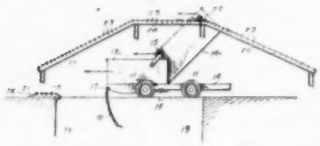
Optical pyrometer. RICHARD P. BROWN and CHARLES P. FREY. U. S. 1,476,486, Dec. 4. In an optical pyrometer comprising in combination, a light standard, a rheostat arranged to vary the intensity of said standard, a scale representing temp. or temp. equivalents having a calibrated relation with respect to said rheostat, said light standard and said scale being simultaneously visible, and means to move said scale and rheostat in synchronism.



Electric resistance furnace. THOMAS A. REID. U. S. 1,477,384, Dec. 11. An elec. fur. structure comprising an open ended and open top metallic casing, a removable metallic top plate for said casing interlocked therewith, an outer base plate, two spaced apart outer side plates, and an outer top plate inside of said metallic casing, all of said plates being of refrac. ht.-insulating mat., an inner base plate, a pair of spaced-apart inner side plates and an inner top plate, all located inside of said ht.-insulating plates and comprising refrac. high-temp. resisting mat., and spaced apart to provide a fur. chamber, and a htg. element for said fur. chamber comprising a plurality of relatively thin refrac. plates constituting a lining for said fur. chamber and a resistor member held in proper operative position in said fur. structure by said thin refrac. plates in coöperation with the plates constituting the inner lining.

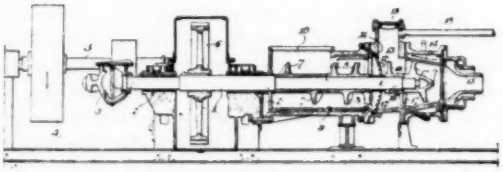
Electric furnace. THOMAS A. REID. U. S. 1,477,385, Dec. 11. In an elec. fur., in combination, a plurality of walls enclosing a fur. chamber, a plurality of relatively thin refrac. plates constituting the lining of said chamber, and relatively thin, shaped, refrac. members located between the adjacent edges of the refrac. plates, and independent of said walls for maintaining them in proper operative positions relatively to each other. See also *Ceram. Abs.*, **2** [6], 136, [9], 207(1923); *Ibid.*, **3** [1], 20(1924).

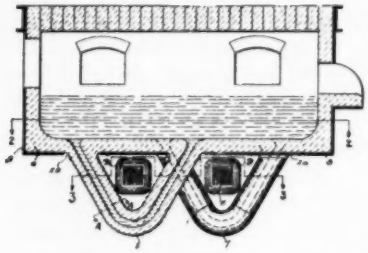
Electric furnace. ORA A. COLBY. U. S. 1,477,313, Dec. 11. An elec. fur. comprising a supporting means and a resistor rod having a plurality of integral flattened portions located in said supporting means.



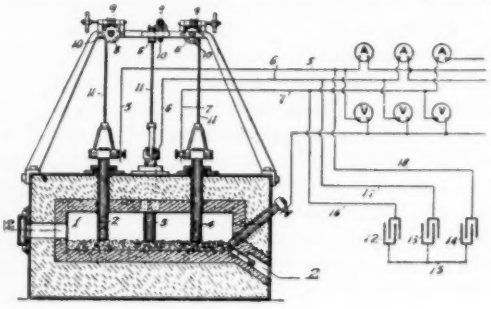
Dumping vehicle. ROBERT C. BLEDSOE. U. S. 1,476,871, Dec. 11. In combination, a wheel supported frame, a relatively stationary body portion carried by the frame and provided with a hinged bottom, a tiltable body portion carried by the frame and having a lip supporting the free end of said hinged bottom, the tilting of said tiltable body releasing said hinged bottom, and means for tilting said tiltable body.

Method and means for working clay. RALEIGH H. STALEY. U. S. 1,478,842, Dec. 25. The method of treating clay, which consists in introducing the clay in a plurality of relatively small streams into an enclosed space, exhausting the air from said space and then extruding the clay therefrom. In a device of the character described, the combination of means forming an enclosed chamber provided with an extrusion orifice, means for forcing clay into said chamber in a plurality of separated streams, means for exhausting air from said chamber and means for extruding the clay therefrom.





Induction furnace. CHARLES A. BRAYTON, JR. U. S. 1,479,582, Jan. 1. In an induction fur., the combination of a bath, a closed channel of uniform cross-section thereunder and connected therewith and leading to and from the bath, said channel having a comparatively thin wall of substantially even thickness throughout its length and surrounded by a pervious metallic jacket, whereby said wall may be maintained at a relatively cool temp. to prevent permeation of the molten metal through the channel wall.



Electric furnace. MORRIS H. BENNETT. U. S. 1,478,375, Dec. 25. The combination with a fur. for melting metals, of means for delivering a main htg. current directly to the charge in the fur. and means for impressing on said main current a htg. current of high

frequency, the resulting current producing improved htg. effects in the fur. due to the resistance of the charge to said current.

Kilns, Furnaces, Fuels and Combustion

The application of tunnel kilns in the firing of ceramic wares. C. B. HARROP. *The Clayworker*, **80**, 34(1923); *Brick and Clay Record*, **63**, 18–19(1923).—An address given at the summer meeting of New Jersey Clay Workers Association and Eastern Section of the AMERICAN CERAMIC SOCIETY. H. brought out that in the use of the tunnel kiln as compared with the periodic operation, there is a saving of 50 to 85% in fuel. Moreover, a higher type of kiln burner is necessary for successful operation of tunnel kiln. A chart was presented (given below) which set forth all tunnel kilns of different types, that have been constructed and operated with more or less success during the past 13 years.

Character of ware	No. of kilns	Character of ware	No. of kilns
Vitreous China	3	Brick and Hollow Tile	15
Semi-porcelain	9	Drain Tile	1
Sanitary Ware	14	Roofing Tile	2
Cooking and Art Ware	1	Electrical Porcelain	8
Stoneware	2	Carbon Electrodes	3
Refractories	6	Abrasives	1
Floor and Wall Tile	12	Specialties	2
Terra Cotta	1		

J. W. H.

Oil firing of clay products. W. D. RICHARDSON. *The Clayworker*, **80**, 142–3 (1923).—On basis of heat units 1 T. of fuel oil is approx. equiv. to 1.46 T. of coal, but on basis of actual opern. 1 T. of fuel oil is equiv. to 1.79 T. of coal. Using this latter figure and considering av. wt. of fuel oil as 7.7 lbs. per gal. the following table gives the equiv. prices of coal at kilns and of oil in storage at kilns.

Oil, price per gal.	Coal, price per ton	Oil, price per gal.	Coal, price per ton
0.02	2.91	0.055	7.99
0.025	3.63	0.06	8.72
0.03	4.36	0.065	9.44
0.035	5.08	0.07	10.17
0.04	5.81	0.075	10.89
0.045	6.54	0.08	11.62
0.05	7.26		

Advantages of fuel oil are given. (1) An equal wt. of oil can be stored in approx. $^2/_3$ of space required for coal, and an equal vol. of oil has 50% greater heating value than coal. (2) Fuel oil does not deteriorate in storage to any appreciable extent. Coal deteriorates in storage. (3) No ashes, clinker or dirt when oil is burned. (4) Smoke almost entirely eliminated. (5) Oil handled cheaper than coal; no handlers or stokers req. (6) A more intense heat can be secured with oil. Also, a more uniform ht. and better regulation. No opening of fur. doors, with an inrush of air and no lowering of temp. from cleaning of fires. (7) A smaller per cent of excess air is required, hence a smaller vol. of waste gases and greater economy. (8) Flue gas analysis shows less fuel is lost through stack. J. W. H.

Oil firing clay products. W. D. RICHARDSON. *The Clayworker*, **80**, 340–2(1923).—Article deals with the atomizing of oil. The three main atomizing systems used are: (1) steam, (2) air, (3) mechanical. The fundamental factors are delivery of oil at a

uniform pressure, free from water and foreign matter, absolute control of all the fuel and air entering the fur. and regulation of the air in propn. to the fuel req. Cuts are given of several burners on the market. J. W. H.

Maintenance and rebuilding of round down-draft kilns. E. E. AYARS. *Brick and Clay Rec.*, **63**, 181–5(1923).—Experience indicates that, when a brick kiln shows age, it pays to rebuild it throughout. Some reasons are given in the discussion of rebuilt kilns (32 ft. pit kilns). This type of kiln has various disadvantages, but affords increased setting capacity and the small flues are more easily cleaned. Foundation is concrete. Tunnel is almost entirely silica brick which is recommended also for the floors and flues. Washing the interior with a clay slip is advantageous if pure high grade clay is used, a high alumina wash gives good results as it does not glaze readily. Repair clays and washes should contain at least 25% of fire-brick bats or calcine ground with clay. Repair clay should pass a 20-mesh and washes through a 30-mesh screen. Shrinkage cracks should be filled with grog to which a small amount of plastic clay is added. J. W. H.

Insulation of kilns. J. H. KRUSON. *Brick and Clay Rec.*, **63**, 22–6(1923).—This article deals with insulation (diatomaceous earth) of walls and crowns of down-draft kilns, used in firing fire-clay refractories. A report from 25 plants using crown and wall insulation estimates a fuel saving from 15 to 25%, while for crown insulation, only 10 to 15% is reported. The total furnace area could be reduced 10% and there would still be sufficient capacity for proper burning. Improved quality of ware is reported. Several graphs showing heat losses through various kiln walls (insulated and bare) and types of crowns accompany the article. Tops should be left bare for two burns to allow for settling, and then should be waterproofed. By proper insulation the wall thickness may be reduced about one-third. J. W. H.

The practical use of oil fuels. A. F. BREWER. *Combustion*, **9** [5], 379(1923).—Prac. suggestions are given on cleanliness, fire hazard, ventilation, soot blowers, pumping and straining, repairing leaks, and flaming at stack. Burners extinguished by clogging, water in oil, too great amt. excess air, occasional slugs of air in oil line. Explosion and flareback caused by attempting to relight from seemingly hot wall, accumulation of explosive gases from leaky burner valve, insufficient ventilation of fur. prior to lighting. Steam and air atomization with air chamber requires 30-50 lb. press., without, 100 lb. press. or over to avoid pulsation. Dry steam is necessary or flame sputters. Mech. atomization requires approx. 150 lbs. press. and oil at nearly const. temp. and press. C. R.

Efficient use of liquid fuel. H. A. ANDERSON. *Foundry*, **52** [1], 29–30(1924).—The efficiency of an oil burning system is greatly dependent on the type of burner, its location in the fur. and the oil and gas press. employed. Insulation shows small savings on fur. operated a few hrs. each day. Light colored surfaces cut down radiation losses. Oil feeding systems are discussed, and the circulating system with a rotary pump recommended. M. E. M.

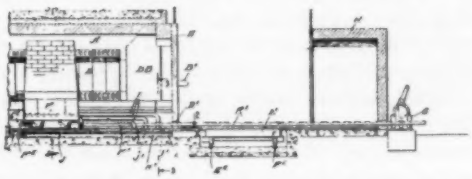
Excess air and fuel consumption in kilns. P. THOR. *Tonind. Ztg.*, **95**, 723–4 (1923).—Firing control app. may often be purchased for the price of 3000–4000 brick which will make it possible to save 30% fuel. This app. is the draft gage which has become indispensable to the brick indus. The draft gage, however, merely gives the variations in draft and does not tell us the compn. of the gases. The CO_2, O_2, CO, and N_2 contents of the chimney gases may be detd. with an Orsat app. or a Cramer chimney gas tester. It is possible to make 20 detn. per hr. with one of these. In regular firing practice it was found that variations in the chimney gases do not always occur in kilns having different diameters but may also occur in the same kiln for reasons not always explainable. Gas anal. of the chimney gases at frequent intervals is the only

safe way to control kilns. In general it may be said that kilns performing the best give a comparatively high anal. for CO_2, this being 7–8%. Poorly performing kilns have a content of CO_2 in their chimney gases varying from 2 to 4%. Where the gas analyses shows a low CO_2 content it indicates that the draft is too strong and considerable fuel is wasted due to the htg. up of excess air. In such cases the resist. to draft should be increased this being most conveniently done by lowering the damper.

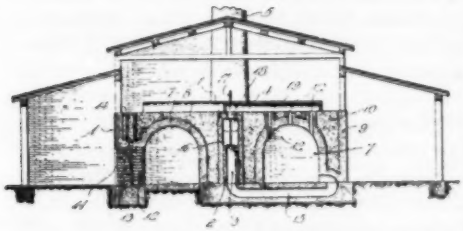
H. G. S.

PATENTS

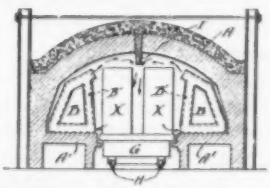
Tunnel kiln. HARRY M. ROBERTSON. U. S. 1,477,152, Dec 11. The combination with a continuous tunnel kiln and the goods carrying cars movable through it, of means for withdrawing the goods carrying cars from the exit end of the kiln comprising a dummy car, means for moving the dummy car into and out of the kiln at its exit end, and means for detachably coupling the dummy car to the goods carrying car.



Brick kiln. BAPTISTE F. CANAVERA. U. S. 1,479,368, Jan. 1. A kiln comprising a central wall whose upper portion is hollow and forms a horizontal flue leading to a stack, the lower portion of said wall having vertical passages in valved communication with the flue and the upper portion of the wall having inlet passages; a continuous tunnel surrounding said central wall and having down-draft flues in its bottom discharging into said vertical passages, the outer wall of said tunnel having temporary fire openings while the crown of said tunnel is formed with fuel feeding openings; and arched transversely disposed conduits resting removably on and extending between the crowns of said tunnel and said horizontal flue, said conduits being in communication with said fuel feeding openings and the upper inlet passages of said horizontal flue whereby to establish communication between the upper portion of the tunnel and the horizontal flue when said conduits are in place.



Continuous tunnel kiln. LAURENCE ARTHUR VINCENT. U. S. 1,477,675, Dec. 18. In a continuous tunnel kiln comprising an elongated kiln chamber with a goods pathway therethrough and combustion chambers extending longitudinally of the kiln chamber at opposite sides of the goods pathway in the high temp. zone of the kiln chamber, whereby the goods are largely htd. by a convection current circulation of the kiln atm. upwardly past the combustion chambers and downward in the central portion of the goods pathway, the improvement which consists in a longitudinally extending baffle in the kiln chamber above the goods pathway.



Geology

Marketing of talc. RAYMOND B. LADOO. *Eng. Min. Jour. Press*, **113**, 963–5 (1922).—Lists, uses, markets and methods of marketing. Describes briefly properties

of crude talc from Vermont, New York, North Carolina, California, Canada, France and Italy. Notes absence of standard specifications. S. L. G.

Soapstone deposit in Ontario. AURION. *Eng. Min. Jour.-Press,* **114,** 1071 (1922).—Wabigoon Soapstone Co., Ltd., organized to develop deposit 200 miles N. W. from Fort Williams. Said to be only workable deposit of soapstone known in Canada. S. L. G.

Non-metallic mineral wealth of Russia. SYDNEY H. BALL. *Eng. Mining Jour.-Press,* **114,** 985–9(1922).—A résumé of resources with historical sketches of production of several minerals. Brief descriptions of distribution and geology of coal, petroleum, clay, salt, asbestos, magnesite, barite, diatomaceous earth, etc. S. L. G.

Feldspar. ANON. Dept. of Mines (Western Australia), *Ann. Rept.*, p. 72(1922).—Feldspar occurs as the chief constituent of a big pegmatite dyke situated near Jacob's Well. A large quantity could be obtained by means of a quarry or open cut. It is slightly kaolinized, suitable for use in pottery and enameling trades. O. P. R. O.

Magnesite. ANON. Dept. of Mines (Western Australia), *Ann. Rept.*, p. 70 (1922).—Deposits of magnesite have been found in the vicinity of Coolgardie, samples of which prove it to be of excellent quality for making Sorrel cement. As the demand for magnesite in recent years has far exceeded the supply the new prospect is of considerable economic importance. It is now used in the manuf. of marbleite, which differs from marble in that the lime is replaced by magnesite. O. P. R. O.

Fluorspar lode. E. C. SAINT-SMITH. *Queensland Gov. Min. Jour.*, **24,** 418(1923).—This fluorspar lode, Chillogoe Dist., Queensland, under review is one of the most important deposits of high quality fluorspar yet recorded in the Commonwealth of Australia. It is of comparatively large tonnage, and economically available. O. P. R. O.

Silica sands. ANON. *Indus. Australian and Min. Stand.*, **70,** 707(1923).—Silica sands of Western Australia are known to compare favorably with those found in any other parts of the world. O. P. R. O.

Ironsand. W. DONOVAN. *N. Z. Jour. Sci. and Indus.*, **6,** 140(1923).—In the ironsand of Taranaki the oxide of a new element has been discovered, which it is stated is a refrac. silicate of titanium. Mineralogically, the Taranaki ironsand consists principally of magnetite, ilmetite, ferro-magnesium minerals, such as augite and hornblende, some olivine and quartz; zircon is occasionally present. From the chemical standpoint the most noticeable feature of the sand is the presence of about 10% of TiO_2. D. gives analyses of various ironsands and a summary of the attempts to manuf. iron from these sands; he is convinced that the recovery and utilization of by-products are essential factors in the manuf. of iron from Taranaki ironsand; but if a process could be devised which would not only produce iron, but at the same time recover the titanium dioxide, an exceptionally good pigment, non-poisonous, with a greater covering power than white lead, and ferro-titanium, often a constituent of pottery glazes, the ironsands would be commercially profitable. O. P. R. O.

The lime belt of Massachusetts and parts of eastern New York and western Connecticut. T. N. DALE. U. S. Geol. Survey, *Bull.* **744,** 67 pp.(1923).—Seven quadrangles with their lime deposits are described. The *calcitic limestones* are classified as (1) those used for finishing lime, (2) those not making the best finishing lime, (3) those discarded on account of accessory minerals, and (4) those discarded on account of texture or content of Mg. The *dolomitic limestones* are classified as (1) those used for magnesian lime, (2) those discarded on account of accessory minerals, and (3) those discarded on account of behavior under fire. Chem. analyses of 13 specimens are recorded and 13 photomicrographs of thin sections are shown. The granular and semi-granular dolomitic limestones are described, also the structure exposed in various

quarries. The relations of geologic formation to cost of quarrying and to future prospecting are indicated. L. W. R. (*C. A.*)

Selenium and tellurium. S. SKOWRONSKI. *Mineral Ind.*, **31**, 621–5(1922).—A review of production and technical progress, with a bibliography. A. B. (*C. A.*)

Talc and soapstone. F. B. PECK. *Mineral Ind.*, **31**, 658–66(1922).—Markets, trade, production and consumption, and properties are discussed. A. B. (*C. A.*)

Chemistry and Physics

The measurement of thermal conductivity. EZER GRIFFITHS AND G. W. C. KAYE. *Proc. Royal Soc.* (London), **104A**, 71(1923).—Thermal condy. is a phys. const. not capable of ready detn. by simple appliances: the aim in the design of app. described has been to produce an equipment which will give the desired data with min. expenditure of time and labor. Three types of app. are described, for rapid precision detn. of thermal condy. of mats. of low condy.; all three types are modifications of the "plate" or "wall" method to which the stand. equation defining condy. (k), $Q = kA.t - \frac{\theta_1 - \theta_2}{d}$ is directly applicable. App. No. 1 was designed for the study of mats. in the form of discs $^1/_2$ mm. to 4 mm. thick and about 45 mm. in diam. This app. is especially convenient for mats. of a slightly compressible nature, such as cardboard and various hard timbers, which could not be tested between amalgamated plates, owing to the penetration of the mercury into the pores of the mat. App. No. 2 was designed primarily for those mats. of which the contact resistance at the hot and cold plates is high and for which the use of amalgamated plates becomes necessary. The design of the mounting of this app. proved also to be convenient for the study of the variation from point to point in the conductivity over the areas of a large sheet of mat., such as ebonite or micanite. App. No. 3 is a somewhat specialized form of No. 2, adapted in the main for carrying out meas. on mats. which are only available in very thin layers (*e. g.*, certain fabrics, micas, and mica compositions), so that the ht. transmitted for an appreciable temp. difference was very considerable. This necessitated the use of a heavier type of heating coil which was totally enclosed in a block of copper. Energy was supplied by elec. means, a meas. of both the energy entering and leaving the test specimen being made. Temps. were meas. by thermocouples. The samples were thin and no guard ring was required. An average time for the attainment of the "steady state" was 30 min. or less, and the average accuracy of meas. of the condy. was about 1%. Among the points dealt with in the paper are the thermal resistance at the bounding faces of a mat., the effect of superimposing layers of compressible mat., the meas. of the thickness of compressible mat., the dependence of the condy. of timber on structure and the moisture content, the variation of the condy. of rubber with mineral content, etc. The figs., illus. and tables accompanying the paper are very comprehensive, Table 13 giving a summary of the results on the thermal condy. of various mats. O. P. R. O.

Solid solutions. W. ROSENHAIN. 1250-N (Preprint), Inst. of Metals Division, Am. Inst. of Min. and Met. Engrs., New York meeting, Feb. (1923).—This paper by R. is the second annual lecture before the Inst. of Metals Division of the Am. Inst. of Min. and Met. Engrs. and deals largely with the internal structure and constitution of solid solns. of metals. A solid soln. is defined as a cryst. body formed from a liquid soln. or from an intimate mixt. of solids, or of liquid and solid, that retains in the solid state an admixture of the two subs. (solvent and solute) as intimate as that which exists in a liquid soln. The manner in which solid solns. are formed is considered on the basis of thermal diagrams of equilibrium. While the questions as to how and why solid solns. form have been answered hitherto on the basis of thermo-dynamical formulas,

this does not really give a satisfactory phys. conception of what actually occurs, and R. develops a purely phys. conception. The nature of the solid-soln. crystal is discussed on this basis and as regards its behavior on melting and freezing. It is pointed out that a solid-soln. crystal is a self-strained structure, owing to its lowered m. p. with increasing concentration. This means that the amt. of kinetic energy that must be communicated to the constituent atoms or molecules of the crystal to bring about disruption or melting is lessened by increasing concentration of the solid soln. Therefore, the crystal itself must contain stored-up energy, and the degree of solid soly. must be detd. by the max. amt. of energy that can be stored. Recently, the results of X-ray crystal analysis have thrown an enormous amt. of light on the structure of crystals and of solid solns. X-ray spectographs show that crystals are built up of atoms arranged upon space lattices, and when the atoms of a pure metal are arranged upon a space lattice, whose dimensions are known, there can be no considerable interstices between the atoms. In considering the formation of a solid soln., the question naturally arises as to where the atoms of the dissolved metal go when they pass into solid soln., and the only feasible view appears to be that they take the place of some of the atoms in the solvent metal, upon its own space lattice. Such substitution must produce a powerful effect upon the whole of the lattice, or at least in the neighborhood of the solute atom. This effect is in the nature of a distortion, and such distortion is greater or less, depending upon the similarity, or otherwise, of the solute atom to the solvent. Moreover, the relative amt. of local and general distortion of the lattice will depend upon the nature of the lattice itself. If the lattice is flexible, the distortion is likely to be mainly local, whereas if stiff, local distortion will be resisted and there will be correspondingly increased general distortion. Measurements by Owen and Prestol of the lattice dimensions in the copper-aluminium solid solns. at the copper end show that the differences between the observed and calculated density figures are very small, and their observations are in accordance with the substitution theory. Of course, the number of solute atoms that can be introduced into the space lattice of a solvent must be limited, but this limit depends upon the amt. of distortion that the introduction of each atom produces. The amt. of distortion that a lattice undergoes determines the extent to which the hardness, strength, and ductility of a crystal are affected. Distortion causes a disturbance of the smooth gliding surfaces by means of which plastic deformation takes place, and thus produces a hardening of the metal. Hence, the hardening effect of an alloying element present in solid soln. is approximately inversely proportional to its solid solubility, and a number of examples of alloys are cited to show that this relationship holds. A property of solid solns., even more typical, perhaps, than hardness, which also finds ready explanation on the basis of the substitution theory, is the lowering of the melting point and the spreading of melting and freezing over a range of temperature. Melting can be described as a separation of atoms on the space lattice beyond a definite limiting distance. Where the lattice is perfectly uniform, as in a pure metal, this separation occurs throughout the whole of the crystal at a single and definite temperature. But in a solid solution, where the lattice is either locally or generally distorted, different parts reach their limiting inter-atomic distance, *i. e.*, their melting point, at different temps. Melting, therefore, begins at a temp. which may be considerably lower than that at which the whole of the crystal becomes liquid. When the solvent metal is hard and strong, and the lattice distortion is therefore general rather than local, there is not much difference in temp. between the beginning and the end of melting or freezing; but when the solvent metal is soft, and the lattice distortion is apt to be local rather than general, wide differences are noted. Striking confirmation of the theory is found from consideration of alloys in which the addition of the alloying element causes a rise in the m. p. This is found to be associated with a contraction of

the lattice dimensions, as opposed to an enlargement in the case where the melting point is lowered, precisely as would be expected from the theory. On the basis of the theory, explanation of the mechanism of how diffusion occurs in a solid soln. is given as well as explanations for solid solns. containing several kinds of solute atoms and for the nature and brittleness of intermetallic compds. R. J. A.

Charts for estimating temperature distributions in heating and cooling solid shapes. H. P. GURNEY AND J. LURIE. *Jour. Ind. Eng. Chem.*, **15** [11], 1170(1923).—A number of charts are graphically represented, simplifying the calcns. necessary in detg. temp. changes occurring in htg. and cooling solid shapes. These include unaccomplished temp. change ratios in slabs, cylinders and spheres initially at uniform temp. and approaching another uniform temp., initially at uniform temp. but with the surface temp. uniformly varying from the initial value and momentary values in semi-infinite solids. Where thermal conductivity, thermal diffusivity and surface emissivity are known, or can be assumed, examples of the calcns. involved are given for slabs of rubber and glass and a steel ingot. These illustrate time necessary for arriving at a uniformly higher temp., time-temp. rate of change at any distance from the surface when temp. is suddenly lowered and temp.-time relations at varying distances from the surface when subjected to uniform temp. rise for a definite time. R. D. L.

The proportion and composition of colloidal matter in clay. A. VASEL. *Kolloid. Zeits.*, **3,** Sept.(1923); *Tonind. Ztg.*, **47,** 726(1923).—V. studied the colloidal content of Meiszen kaolin by detg. the per cent of fine clay sol. in an HCl sol. This clay was composed of 32.47% quartz, 65.03% clay subst. and 2.50% feldspar. It had a sp. gr. of 2.583. 10 gms. of clay were boiled in 200 cc. of 10% HCl for 4 hrs. In a 2nd series of tests it was boiled in a 5% sol. of HCl for 6 hrs. In a 3rd series the sol. was first poured off after standing 4 weeks. In each case the residue was had with NaOH (sp. gr. 1.04) in order to remove any silicic acid which may have been formed. The mol. amt. of Al_2O_3 and SiO_2 varies as follows, using Al_2O_3 as unity: 1: 2.08, 2.06, 2.01, 2.19, and 2.22 showing that these constituents are present in the clay in approx. the kaolinite ratio. 3% of mat. was removed from the clay by these treatments so V. concluded that this clay has at least 3% colloidal matter since only the extremely fine grained mat. would be dissolved by this treatment. The clay, however, was equally as plastic after this mat. had been removed as it was before the treatment. Hence it must be that only a portion of these colloids was removed by the treatment.

H. G. S.

Chromium oxide and salts, chromates, barium chloride. A. B. MOND (Chemische Fabril Griesheim-Elektron, Germany). Brit. Pat. 25,720, *Oil & Color Trade Jour.*, **64,** 2186(1923).—Alkali chromates; chromium oxides and salts; barium, chromium, and iron chlorides. Chrome iron ore is converted into ferrochromium in the known manner, the ferro-chromium is dissolved in hydrochloric acid and the chromium pptd. as hydrated oxide by calcium or barium carbonate. The ppt. is sepd. and used to produce alkali chromate, or chromium salts. The filtrate, if barium chromate is used, is evapd. and cooled to separate barium chloride, and the mother liquor may be evapd. to obtain ferrous chloride. In the pptn. of the chromium hydrate it is preferred to use granular limestone or witherite and hot chloride soln. O. P. R. O.

Thermal conductivities of some metals in the solid and liquid states. W. BYRON BROWN. *Phys. Rev.*, **22,** 171–80(1923).—Thermal conductivities of some metals and eutectic alloys above and below their m. p., 50° to about 400°C. A guard ring method of measurement was used. A cylindrical rod of the metal, 1.5 cm. diam. and 12 cm. long was surrounded by a slate tube and outside that a hollow brass cylinder. Both rod and cylinder were independently heated elec. at the top and cooled by flowing water at the bottom so as to maintain the same temp. gradient in both, as shown by thermo-

couples. The input of energy into the rod was corrected slightly for heat leakage and divided by the temp. gradient times the area to get the condy. The conductivities of tin and cadmium decrease at the m. p. by over $^1/_3$ and $^1/_2$, respectively. For thallium, there is a drop of $^1/_{10}$ at about 120°C indicating a polymorphic change. The temp. coeff. are about the same before and after melting, being -5×10^{-5} (Sn), $+21 \times 10^{-5}$ (Cd), $+8 \times 10^{-5}$ (Th). For the eutectics: Sn 0.92, Zn 0.08; Sn 0.62, Pb 0.38; Pb 0.87, Sb 0.13; Pb 0.46, Bi 0.54; the temp. coeff. for the liquids are all positive and have values at 300°C, from .0011 (Pb — Bi) to .0030 (Pb — Sb) close to those found for gases at that temp., indicating that the mechanism is similar in the two cases. Below the m. p. the curves vary, one increasing with temp. (Sn — Zn), two decreasing, and one reaching a max. (Pb — Sb). The sudden decrease on melting varies from $^2/_3$ for (Sn — Zn) and (Pb — Sn) to $^1/_{10}$ for (Bi — Pb). A. F. G.

Thermal conductivities of metal crystals. I. Bismuth. KAYE AND ROBERTS. *Proc. Royal Soc.*, **104A,** 98–114(1923).—All accurate measurements of the thermal condy. of metals have heretofore been made on bars of heterogeneous structure. It was thought desirable to compare the values so obtained with the more fundamental ones given by single crystals. Expts. have been carried out in the first instance on bismuth as it is easy to obtain large crystals and it is one of the few metals that does not crys. in the cubic system. A "plate" type of thermal condy. app. was developed for the purpose. A clearly designed diagram of this app. is given and a detailed description of the construction of the hot and cold plates, the thermal insulation and the surfaces of contact. The results give the thermal conductivities of single crystals of metallic bismuth in directions parallel and perpendicular to the trigonal axis. Two very complete tables indicate these results and are so arranged that each group corresponds to one setting of the specimen. The following are the mean values at 18°C, in c.g.s. units.

Thermal conductivity of bismuth parallel to trigonal axis	0.0159
Thermal conductivity of bismuth perpendicular to trigonal axis	0.0221
Ratio of conductivities	1.39

If a random distribution of crystals is assumed, these figures give a mean condy. of 0.0195, which agrees well with the value 0.0193 obtained on bars by JAEGER and DIESSELHORST in 1899. O. P. R. O.

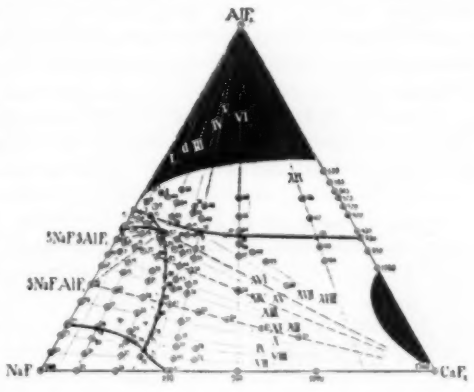
Heat effects on fire clays and their mixtures. SHINJO SATOH. *Sci. Rept. Tôhoku Imp. Univ.*, **1** [3], 156–201(1923).—S. treats the problem from every angle illusg. his remarks with tables and plates. The subject is dealt with under the following headings:—(1) Thermal expansion and contraction. (2) Endothermal and exothermal reaction of raw clay. (3) Detn. of the dehydration point of clay with thermo-balance. (4) The change of the microstructure of clay by heating. (5) Erosion of clay subs. in contact with molten glass. (6) Microstructure of stone. (7) String or cord. The results are summarized as follows: (1) The firing contraction of raw mats. of fire clay is classified into 2 types, one of which expands at a comparative low temp. while the other contracts without a marked expansion. (2) Firing contraction of a fire clay mixt. is the resultant of contractions of the constituent clays. Therefore, the shape of the firing contraction curve and the amt. of the final contraction vary with the mixing ratio of the constituent clays. (3) The thermal change of length of the mold made of fire clays, when heated above a definite high temp., is irreversible. (4) When the mold of clay is htd. at a definite constant temp., the contraction curve of the length satisfies the following equation: $\frac{x}{C-x} = \frac{A}{C-A} - Kt$, where x is the amt. of contraction

at time t, A an initial length of the specimen, C the final contraction after heating infinitely long at a constant temp., and K a constant. Hence we can calculate the final contraction C by means of this equation by three observations. (5) From the results of the thermal analysis, the thermo-balance test, and the microscopic investigation, we can draw the following conclusions:—(*a*) The dehydration of the constitutional water of kaolinite takes place between 400°C and 600°C. (*b*) It seems very probable that the dissociation of kaolinite into aluminium silicate and free silica commences at 650°C. (*c*) The internal change takes place between 900°C and 1000°C, it is probably a polymerization of the dissociated aluminium silicate. (*d*) Between 1200°C and 1300°C, we have also another internal change, which may be taken as the result of recombination of free silica and aluminium silicate formerly dissociated at lower temp. (6) Stones may be classified into 4 kinds:—(*a*) Unfused quartz grains coming from pot material. (*b*) Unfused quartz grains coming from glass batch. (*c*) Clay subs. coming from pot mat. (*d*) Insol. foreign mineral coming from pot mat. as well as glass batch. (7) Some precautions for elimination of the stone in the glass, and the cause of the formation of string have been discussed. O. P. R. O.

Graphical representation of rock analyses. J. Stiny. *Centr. Mineral. Geol.*, **1923,** 392–3.—Results are plotted on cross-section paper. Ordinates are %, abscissas SiO_2,-Al_2O_3, K_2O, etc., spaced at equal intervals. Plotting starts with SiO_2. The % of each of the remaining oxides is added to the sum of all the preceding ones and the total plotted. By joining the points so obtained, a line results which is characteristic for each rock family. J. E. G. (*C. A.*)

Fusibility of the ternary system: sodium fluoride, calcium fluoride, aluminium fluoride. P. P. Fedotieff and W. P. Iljinsky. *Z. anorg. allgem. Chem.*, **129,** 93–107 (1923).—The results of the study are given in the accompanying diagram. The black portions denote the unrealizable regions. The invariant points occur at 780, 705 and 675°.

J. A. A. (*C. A.*)



The electrical conductivity of solid and fused silicates. C. Doelter. *Rec. trav. chim.*, **42,** 729–32(1923).—A few silicates conduct at room temp. but at 1000° nearly all silicates become conductors. Results on the condy. and polarization of fused silicates are described. The detns. of polarization, especially, showed that even in the solid state electrolytic condy. is present in the silicates examd. In the fused state it is often large. From this D. concludes that ions are present even in the solid silicates but that they are firmly bound in the space lattice and for this reason the condy. does not appear until the ionic mobility is increased by raising the temp. D. has not detd. whether the condy. varies in different directions through the crystal. The existence of ions in crystals does not contradict the recent views on crystal structure. E. J. W. (*C. A.*)

Experiments on the expansion of ceramic mixtures. G. Capsa. *Bul. soc. chim. România*, **5,** 5–11(1923).—Emphasis is laid on the protracted expts. necessary to det. the influence of different ingredients and conditions during burning on the coeff. of expansion of faience. C. C. D. (*C. A.*)

General

Ceramic industry in Czecho-Slovakia. RUDOLF BARTA. *Rev. Mat. Constr. Trav. Pub.*, **170**, 209–10B(1923).—I. *Raw Materials.* Percentage chem. analyses of some important raw materials and their fusion points are given.

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	KNaO	H_2O	Seger cone
Kaolin, Zettlitz (Sedlice)	45.92	38.17	0.50	0.15	0.11	1.10	13.95	(35)
Clay, Vilstajn	46.35	33.77	1.11	..	...	0.33	13.44	35
Clay, Mecholupy	46.42	36.67	0.56	..	...	..	16.68	35
Clay, Lisany	46.05	38.19	1.29	..	...	0.63	13.80	35
Clay, Blansko	50.03	35.29	1.57	0.42	0.49	0.50	12.05	34
Schistose clay, Rakonitz	52.50	45.22	0.81	..	...	0.50	0.78	36
Schistose clay, Janusov	43.38	42.07	0.80	0.18	0.20	0.21	14.25	37
Quartzite, Bohemian	97.79	1.41	0.13	0.11	0.19	0.39	0.25	..
Magnesite (Old Austrian)	3.03	7.12		2.25	87.60	..	...	..
Feldspar, Meclov	63.78	21.41	0.15	0.12	0.07	13.70	0.29	..

The Zettlitz kaolin contains 0.05% TiO_2. The alkali of the Meclov feldspar consists of 12.45% K_2O and 1.25% Na_2O. II. *Ceramic Products*, consist of porcelain, refractories, wall tile, paving blocks, stoneware pipe, brick, building tile, Portland cement and lime. III. *Ceramic Instruction and Technology.* Ceramics is taught in two polytechnic schools, at Prague and Brno, and in 4 indus. schools, at Bechyne, Plzen, Teplice and Znojmo. Among the scientific organizations are the Institute for silicate industries, the Institute for glass and ceramics. Standardization work is carried on by the Association for testing and exploiting of technical products. The "Société céramique tchéco-slovaque" has been lately founded at Prague and will publish its proceedings. L. N.

The unity of English weights. SAMUEL RUSSELL. *Science*, **58** (1509), 442(1923).—The author defines the English pound of which there is but one, weighing 7000 grains. He points out that the Troy pound no longer exists. The Troy ounce, however, is in common use. There is some confusion in Amer. in the use of the fluid ounce; we ought to adopt the Brit. system in which a fluid ounce is the volume of $^1/_{16}$ pound of water. The author recommends that the Brit. fluid ounce shall be our "standard ounce" and that it be decimalized. The use of the so-called long ton ought also to be abolished by law. C. J. H.

Combustion phenomena. E. KIEFT. *Combustion*, **9** [5], 390(1923).—The ht. value of a fuel is a function of its commercial value, not necessarily proportional to B.t.u., and depends also on compn., purpose and place of use. The phys.-chem. considerations of ht. transfer, combustion, and luminosity are discussed and illusd. C. R.

The making of earthenware, up to and including the first firing of the clayware. E. SHENTON. *Pottery Gaz.*, **48**, 1789–99(1923).—Address deals with origin of clays, methods of grinding, blunging, compounding of body, throwing, turning, handling, jiggering, casting, finishing, mold making, biscuit placing and firing as in English potteries. J. W. H.

No standard specifications for feldspar among producers and consumers. "CONSULTATION." *Eng. Mining Jour.-Press*, **114**, 1077(1922).—"Producers and consumers may have agreements that serve in lieu of standard requirements but they are a matter of individual negotiation rather than universal trade recognition ....." S. L. G.

Industrial analysis. ANON. *Eng. Mining Jour.-Press*, **113**, 81–97(1922).—Discusses production and markets for manganese, chromite, nickel, tungsten, molybdenum,

vanadium, uranium, radium, arsenic, barytes, bauxite and aluminum, borax, fluorspar, graphite, magnesite, talc and mica. S. L. G.

The non-metallic minerals. WARREN M. FOOTE. *Eng. Mining Jour.-Press*, **113**, 242–6(1922).—Review 1921 production of pumice, asbestos, graphite, limestone, pyrite, talc, clay, silica, bauxite, fluorspar, magnesite, chalk, sulfur, emery, gypsum, barytes, borax, phosphate rock and mica. S. L. G.

Future of non-metallic minerals. R. B. LADOO. *Eng. Mining Jour.-Press*, **113**, 146–7(1922).—Brief analysis of conditions and tendencies in mining, milling, etc. S. L. G.

Status of pulverized fuel. L. W. W. MORROW. *Elec. World*, **82**, 525–32(1923).—Advantages of the use of pulverized fuel in central stations include decreased losses and greater flexibility in operation. However, it cannot be assumed that its use is advantageous in all cases. Several installations are discussed and illus. Concrete bins allow longer storage than steel. For best results, 65% of the coal should pass 200-mesh, and it should contain less than 5% moisture. Below this figure, driers are unnecessary but if used tend to prevent clogging of the conveyors and consumption of more power in handling. W. H. B. (*C. A.*)

BOOK REVIEW

The Chemistry and Physics of Clays and Other Ceramic Materials. By A. B SEARLE. 1924. 695 pages. Ernest Benn, Ltd., Publishers, 8 Bouverie St., E. C. 4, London, England. Price, 55 shillings, net.

A clear and concise text covering the physical and chemical laws controlling the behavior of clays and all other ceramic and related materials. Also an excellent collection of data on the physical and chemical properties of the materials employed in ceramic manufacture and of other minerals and materials for which the ceramist would have an interest.

The data is presented in table form in nearly all cases and represents a very thorough search of scientific literature presented in a convenient form for use in the factory or laboratory.

The title of the volume fails to indicate that it contains a very large amount of data on the physical and chemical properties of burned ceramic products. This data is among the most valuable of the book's contents.

The book has the further advantages of an excellent table of contents and index which will commend it to many as a reference volume.

The material presented is in chapter form and may be briefly described as follows:

1. Physical Structure.—A brief treatise on crystalline and amorphous solids, pastes, slips, colloids and states of aggregation encountered in ceramic materials. Also mode of occurrence of ceramic materials and methods of reduction.

2. Properties Depending on Structure.—Shape and proportioning of grain size and influence on the product; methods of test, and influence and control of homogeneity, porosity and texture in the product.

3. Color, Hardness and Minor Physical Properties.—Natural and artificial sources of color in clays and the causes of discoloration; hardness, and its determination; effect of temperature on hardness of the product.

4. Strength and Allied Properties.—Forms of strength and factors affecting strength in raw and burned clays and bodies with data and test methods.

5. Specific Gravity and Density.—Explanation of the factors affecting these properties in ceramic bodies with test data.

6. Changes in Physical State Effected by Water.—General discussion of clay-water mixtures and their properties, including colloidal phenomena and the causes and measurement of plasticity.

7. Changes in Physical State Following the Removal of Water.—A brief presentation of the theory of drying of clays.

8. Chemical Constitution of Ceramic Materials.—The elements, laws of chemical combination and multiple proportions, atomic and molecular weights, valency, modes of expression, constitution of ceramic materials.

9. The Chemical Components of Ceramic Materials and Products.—Sampling, interpretation of analysis, impurities in clays and effect of composition on utility, general description of types of clay and types of ceramic ware with chemicals and percentage compositions, the Seger cones 022 to 42, various methods of expressing refractoriness, the chemical formulas of engobes and glazes of all types with methods of control and adjustment, and chemical compositions of all the important refractories.

10. The Mineralogical Composition of Ceramic Materials Including the Clays and Related and Associated Minerals.

11. Physical.—Chemical Reactions between Ceramic Materials.—The nature and type of chemical reactions and the influencing factors with explanation of equilibrium diagrams and description of physico-chemical processes.

12. Heat and Temperature.—Their measurements, thermal capacity, heat transmission, and heat and temperature measuring apparatus.

13. The Effect of Heat on Ceramic Materials.—During drying and burning, with finishing temperatures of different types of ceramic ware, the properties of the burned products, and a table of melting points of ceramic materials.

14. Electrical and Magnetic Properties of Ceramic Materials.—Data on electrical conductivity and specific resistance and the effect of composition on the electrical and magnetic properties of ceramic bodies.

15. Optical Properties of Ceramic Materials.—Description and data regarding refractive indices, birefringence and other optical properties of ceramic materials and manufactured ceramic wares.

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of the

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A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical and Scientific Questions and Promotion of Coöperative Research

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Vol. 3 **March, 1924** **No. 3**

EDITORIAL

OUR LEADERS

How to Find Facts
How to Recognize Facts
How to Use Facts

February was the birthday month of two of America's foremost leaders, George Washington and Abraham Lincoln. The thought from the lives of these two men to be developed here is that at all times throughout their youth and their later years of service, they were in constant studious application of fact-finding and using. School days were not their limit of time devoted to study.

Such is the record of every man who is successful through his own efforts. It is the untiring and "always at it" application that makes big industrial successes from small beginnings. It requires a continual drive to find, to recognize and to use facts.

A University graduate employed by a concrete contracting concern applied to this office for information on calculation of openings in revolving screens. He had not learned how to find facts. He probably will never know how to recognize facts and to use facts, largely because he had no plan for working diligently and systematically; he was not educated and was making no effort to acquire an education.

Education can be summed up in this three-fold formula of how to find, how to recognize and how to use facts. This is why schooled-trained men have no monopoly on education, and at the same time, it is the cause for so many college graduates being without an *education*.

"Broke at Fifty" is the title of a story written by R. L. Dollings of his eighty million dollar failure. His opening paragraphs have as their central thought that being broke at 13 or 22 when you are physically most fit, and when fear is an unknown quantity, and when the beckon of adventure is more than welcomed is not so serious a matter, but being broke at 50 is really serious. At fifty the machine is worn, some of the assurance is gone; "hesitation has succeeded the dash of impulse" and the nearness of the inevitable rainy day is evidenced by "just a mist at first and only a few scattered clouds, and you think you are as fit as ever, but life is the old story of the prize ring—the good old man will always go down before the good young man."

What a warning, what a sermon by one who by experience knows. But Youth will not be told; he will not take heed. It will be the oft repeated story of neglected use of Youth's opportunities and fitness to acquire.

The big idea of the AMERICAN CERAMIC SOCIETY is to inspire and to assist young men to acquire the education of how to find, to recognize and to use facts so that when he reaches the age when his faculties are less keen and his ability to acquire habits is very much less, he will have acquired the educational habit and impetus for which and only for which salaries are paid. The SOCIETY not only aims to furnish the inspiration but also the assistance in the acquiring of these fact finding and using requisites. It is for mutual help in furnishing the inspiration and assistance which no one laboring alone could acquire that the members of the SOCIETY are collaborating.

General Washington learned the importance of united effort. He influenced the writing of this lesson into the Constitution of the United States. President Lincoln's prime motive was preservation of this Union of effort. The principle holds in educational affairs as it does in statesmanship.

PAPERS AND DISCUSSIONS

A DUST COLLECTING SYSTEM[1]

By B. E. Whitesell

ABSTRACT

This paper describes the principle on which a dust collecting system installed at the Salina Plant of the Kier Fire Brick Co., Pittsburgh, Pa., operates. It also includes some of the factors considered in the designing and a description of the installation and operation.

Principle on Which the System is Based

Dust-laden air can be conveyed through pipes by connecting them to an exhaust fan, the fineness and specific gravity of the dust determining the velocity head necessary to convey the dust to the point desired. The volume of air required to carry the dust depends on the size of the dust particles and weight per cubic inch, as well as the dust hood necessary to retain the dust at its source.

Fig. 1.

For a given fan, piping system and density of air, the following relations hold: cubic feet of air per minute (c.f.m.) varies as the revolutions per minute (r.p.m.); pressure α (r.p.m.)^2; brake horsepower (b.h.p.) α (r.p.m.)^3. It is evident, then, that the less air handled, the less h. p. will be required. In order that the most benefit may be derived from this fact, under working conditions, dampers are installed near the fans and bins so that any part of the system not in use can be shut off, resulting in a still further decrease of h. p. required, as this portion of the air is not handled.

The proper place to collect the dust is at its source, since the more it is allowed to spread the more air that must be handled and purified; and since the volume of air and its required velocity determine the size of pipes a system permitting of smaller pipes, simplicity, efficiency, and less cost to install and operate would result. The cost of installation increases in direct ratio to the volume of air handled.

[1] Recd. Dec. 29, 1924. Presented at the Atlantic City Meeting, February, 1924. (Refractories Division.)

By providing a means of dust separation (the arrester in this case) the air velocity through such is reduced below that value of velocity head that will move or carry the dust, thus depositing it in the bins of the arrester. Again, if baffle plates are used to reduce the air velocity, the settling action or separation of dust and air is increased.

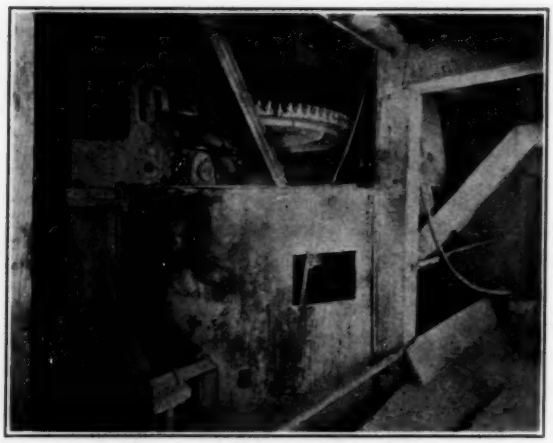


FIG. 2.

The arrester screens being of suitable mesh, the remaining fine particles of dust are taken from the air, leaving it clean as it passes to the outside or is returned to the building for heating purposes.

Designing

This system was designed to take care of four dry pans and three plastic clay bins.

The hoods over the dry pans were designed so that the dust would be confined in the smallest space possible. They were also made as tight as working conditions would permit so as to limit the amount of air entering in order to concentrate, as much as possible, the dust content per cu. ft. of air. The first hood constructed is shown in Fig. 1. A better construction and the one recommended is shown in Figs. 2 and 3, this hood being simpler to build and permitting of easier removal for repairs to the dry pan.

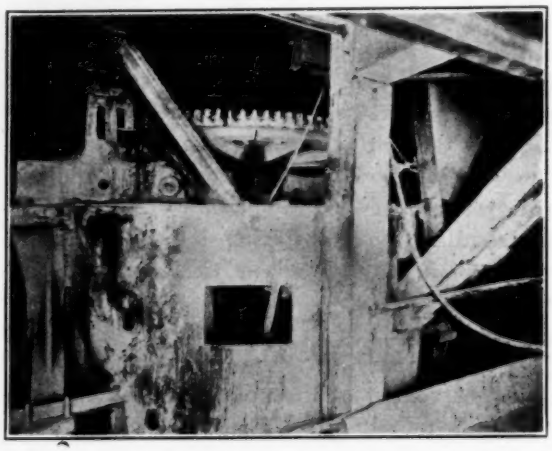


FIG. 3.

Careful consideration was given to the amount of dust that would be handled; the size of particles, in order to reduce the rate of abrasion in the galvanized steel pipes, together with an equally important value, namely, as little

loss as possible in friction in order to make the whole installation cost a minimum h. p. operation; and to the static pressure lost in the entire system.

Considering all the above items, the selection of the proper size arrester, fan and pipes is very important.

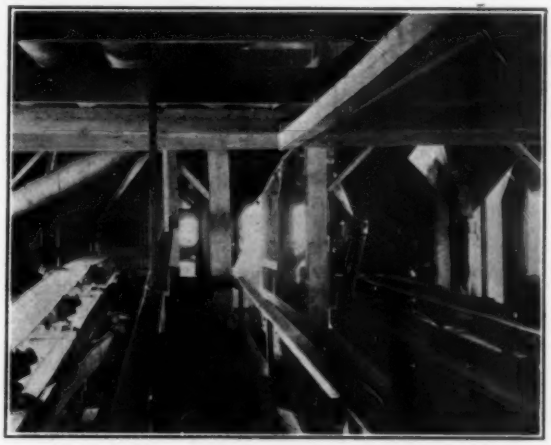


FIG. 4.

Description of Arrester

The arrester is manufactured by the W. W. Sly Manufacturing Co., Cleveland, Ohio.

It is of the cloth screen type containing large areas of filtering surface confined in a comparatively small space.

Cloth is claimed by the manufacturers to be a better filtering medium and should be fairly open so as not to produce too much back pressure. The threads should be fine as possible to make the weave loose and durable. The loose fibers on the individual threads, or the nap of the cloth, make the air passages so fine that practically the smallest particle of dust will be retained.

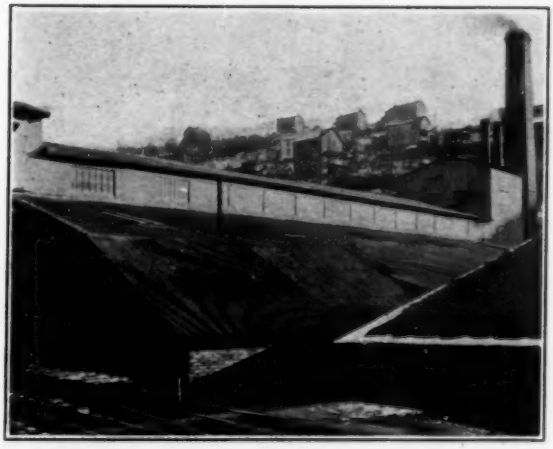


FIG. 5.

Each screen, being 9 feet by 3 feet $4^3/_8$ inches, is double, which gives it an area of 60 square feet. Since there are four screens to the running foot and the arrester is 18 feet long, there is a total screen area of 4320 square feet.

The greater the filtering or screen area in proportion to the volume of air, the looser the dust will lie on the cloth, which is important because the velocity of the air through the cloth should be low so that none of the dust will be drawn into the meshes, but will form a very loose and

fluffy layer on the surface without obstructing the passages of air to any great extent. Also, the screen will retain its filtering capacity longer without shaking the dust down.

The removal of dust accumulation from the screens is accomplished by a rapping device direct driven from a 1 h. p., 1200 r.p.m. motor.

The arrester, the inside dimensions of which are 9 feet $10^5/_8$ inches high plus 3 feet 10 inches for the hoppers, 7 feet 10 inches wide and 18 feet long, is divided into two sections, an 8-foot section and a 10-foot section. The 8-foot section collects from the pan grinding plastic clay and three plastic clay bins, while the 10-foot section collects from the three pans grinding the mixes for the brick machines.

Location of Arrester

The arrester is located directly over two storage bins which permits the hoppers of the arrester to be emptied directly into the bins The location can be seen in Figs. 4 and 5.

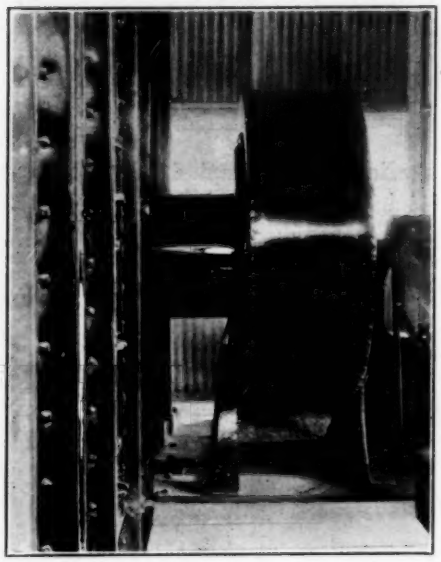


FIG. 6.

Fan

A No. 23 ES special steel plate exhaust fan, made by the American Blower Company, was chosen. It has a large diameter wheel of proper blast area to handle approximately 12,000 c.f.m. operating at 780 r.p.m., requiring under this condition 18.8 h. p. measured at 70°. The fan is shown in Fig. 6.

A type ES, 20 h. p., 1160 r.p.m. Westinghouse motor, having an 8-inch diam. pulley is used to drive the fan.

Pipes

The size of the pipes or branches necessary to carry the dust from the dry pans was first determined.

Each of the plastic clay bins is provided with a 7-inch pipe or branch; each of the dry pans grinding the standard mixes, consisting of flint clay ground to 3-mesh and finer, plastic clay of 30-mesh and finer, and grog or crushed brick bats, is provided with a 9-inch branch; while the pan grinding plastic clay and fire clay to 30-mesh and finer has a 10-inch pipe leading from it to the plastic clay side of the arrester.

These three branches from the bins are connected to a main pipe.

At each point where a branch enters the main, the main pipe area is increased an amount equal to that of the branch added, so that this main pipe increases from 7 inches at the farthest point from the arrester to 13 inches where it enters the arrester. This main also leads to the plastic clay section of the arrester. The three 9-inch branches from the dry pans are connected to a main whose smallest diameter is 9 inches and the largest diameter (the point where it enters the arrester) being 17 inches. This pipe enters the other section of the arrester. Fig. 7 shows the three main pipes entering the arrester.

Besides being designed with the easiest elbow turns (45° or less), as few angles as possible are used.

The main pipes are made of 20 ga. galvanized steel and the branches of 22 ga. All joints are riveted and soldered, keeping the bottom side level.

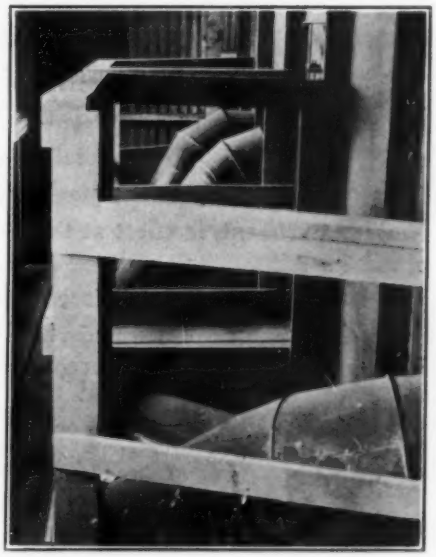


FIG. 7.

Operation

The man in charge of the clay distributing belt has charge of the dust arrester. About ten minutes of his time is required to look after the arrester and motor each day, except one day each week when he inspects the entire system. This requires about one hour.

In the evening, after the day's run, the fan is stopped and the rapping device is run for three minutes to shake the fine dust from the screens. If the fan is running while the screens are being rapped there is a tendency for the dust to be drawn through the cloth into the clean air side of the arrester. After rapping the screens, the gates at the bottom of the hoppers are opened and the hoppers allowed to empty, the plastic clay emptying into a plastic clay bin and the standard mix emptying into a flint clay bin by gravity.

The system is then ready for operation the following morning.

Remarks

It is difficult to get the average amount of dust collected daily, since the plastic clay dust will vary from 150 to 400 pounds for eight hours and the standard mixes from 120 to 180 pounds per pan for eight hours, depend-

ing on the condition of the clay as it enters the pan and the amount of water added in the pan. The clay contains enough moisture when it leaves the pans so that it can be conveyed to the machines by conveyors and chutes without causing any dust. In an operation where no water is added the amount of dust collected would be considerably increased.

Between 450 and 500 pounds of dust are collected during the ten hours required for the grinding of one car of fire clay.

Screen analyses show that 99%+ passes through a 200-mesh screen and 100% through a 150-mesh.

The system has been in operation thirteen months and the only expense has been the repainting of the inside of the arrester. This was done while a thorough inspection was being made of the entire equipment.

THE KIER FIRE BRICK CO.
PITTSBURGH, PA.

BUREAU OF ENGINEERING SPECIFICATIONS, LENSES AND GLOBES[1]

General Specifications

1. General Specifications for the Inspection of Material, issued by the Navy Department, in effect at the date of opening of bids, shall form part of these specifications.

Classes and Grades

2. Glassware furnished under these specifications shall conform to the following classes and grades, as specified in the requisition or schedule.

CLASS 1

NAVY STANDARD FRESNAL LENSES

Grade	
A	Clear
B	Red
C	Green
D	Blue

CLASS 3

NAVY STANDARD GLASSWARE

Grade	
F	Translucent
G	Red globes
H	Green globes
I	Blue globes

CLASS 2

Grade	
E	for Navy Standard heat resisting clear globes

Material, Workmanship, etc.

3. The material and workmanship shall be first class in every particular. The terms "Lead glass," "Lime glass," "Zinc glass," "Zinc-borosilicate glass," "Borosilicate glass," and "First class workmanship," as referred to in these specifications, shall be defined as follows:

[1] Received Dec. 1, 1923. Presented at the Atlantic City Meeting, February, 1924. (Glass Division.)

(*a*) *Lead glass.* A glass composition which contains not less than 22% of lead oxide in the finished lens, and whose specific gravity is not less than 2.90.

(*b*) *Lime glass.* A glass composition which contains between 3.5% and 5% of lime (CaO) and less than 15% of lead oxide in the finished glassware and whose specific gravity is not less than 2.60.

(*c*) *Zinc glass.* A glass composition which contains between 12% and 15% of zinc oxide (ZnO), less than 15% of lead oxide, is free from any appreciable lime (CaO) in the finished glassware, and whose specific gravity is not less than 2.60.

(*d*) *Zinc-borosilicate glass.* A glass composition which contains not less than 7.5% of boric anhydride and between 13% and 15% of zinc oxide in the finished glassware, and whose specific gravity is not less than 2.50.

(*e*) *Borosilicate glass.* A straight boric anhydride glass containing not less than 13% of boric anhydride, not more than 1.5% of aluminum and iron oxides, and free from all other metallic oxides. The specific gravity shall be not less than 2.28. This glass is for Class 2 (heat resisting) glassware only.

(*f*) *Workmanship.* First class workmanship shall mean, among other things, that all finished glassware shall be free from air bubbles, striae, wrinkles, mold marks, chipped edges or any other blemishes which may affect its optical qualities, mechanical strength or good appearance; uniformity in the thickness of illuminating glassware, uniformity in the color density of all colored glassware, and a uniform refractive index for all glassware of the same class and grade furnished under one contract; and having finished dimensions coming well within the tolerances specified on the drawing.

General Requirements

4(*a*) All glassware shall be in strict accordance with the Navy drawings specified in the requisition, order or schedule.

(*b*) Where the thickness tolerances are not shown on the drawing a variation of 12% above or below the nominal dimension will be permitted, provided, however, that this tolerance shall in no case exceed $^1/_{16}$ inch. Where the tolerances are shown on the drawing the permissible variation shall be within the limits shown thereon.

(*c*) The edges of all lenses, globes or shades shall be either ground or molded to a true surface.

(*d*) The refractive index of the glass for any purpose is optional with the manufacturer but this index shall be uniform for that product. The manufacturer shall state to what index base the calculation of the lens contour has been developed, in the design of the Fresnal lenses. This

information shall be furnished the Inspector when material under a Navy contract or order is submitted for inspection.

(*e*) Glassware shall be in strict conformity with Tables I and II hereunder, with respect to color density and light transmission. Table I is given in terms of the actual transmission of light in percentage of the light source, on the basis of the candlepower standard. Table II is based on the standards of the Railway Signal Association at 100%.

(*f*) All colored glassware shall be of uniform color density per millimeter thickness, and the glass shall be solid color. Flashed glass will not be satisfactory.

TABLE I

TRANSMISSION IN ACTUAL PER CENT OF LIGHT SOURCE ON CANDLEPOWER BASIS

Class	Grade	Type	Per cent normal	Per cent maximum	Per cent minimum	Per cent deterioration after 1 year service
1	A	Navy Standard Clear	95	100	90	10
1	B	Navy Standard Red	7.5	9.4	5.6	20
1	C	Navy Standard Green	2.75	3.5	1.75	25
1	D	Navy Standard Blue (L. V.)	0.75	0.90	0.60	25
2	E	Navy Standard Clear (H. R.)	0.80	87	70	15
3	F	Navy Standard Translucent	65	100	50	10
3	G	Navy Standard Red Globes	9.35	10	7.5	20
3	H	Navy Standard Green Globes	11.6	12.5	10	25
3	I	Navy Standard Blue Globes (L. V)	0.75	0.90	0.60	25

TABLE II

TRANSMISSION ON BASIS OF RAILWAY SIGNAL ASSOCIATION 100% STANDARD

Base 100% Red = 9.35% Actual Transmission
Base 100% Green = 11.6% Actual Transmission

Class	Grade	Type	Standard	Light limit	Dark limit
1	A	Navy Standard Clear	...	...	...
	B	Navy Standard Red	100%	100	60
	C	Navy Standard Green	100%	30	15
	D	Navy Standard Blue (L. V.)	...	...	...
2	E	Navy Standard Clear (H. R.)	...	...	...
3	F	Navy Standard Translucent	...	...	...
	G	Navy Standard Red Globes	100%	107.7	86.2
	H	Navy Standard Green Globes	100%	106.9	80.2
	I	Navy Standard Blue Globes (L. V.)	...	...	...

(*g*) All glassware furnished under these specifications shall have the manufacturer's name or trademark permanently impressed in each piece. In the case of Lenses (Class 1) this marking shall be made in the central zone or bull's eye. Heat resisting globes (Class 2) shall have this marking on the outer surface of the globe, near the edge. Globes for general illumination (Class 3) shall have this marking molded or pressed on one edge.

Detail Requirements

Class 1. Lenses

5(*a*)1. Fresnal lenses for navigational and signal lights. The glass shall be of such composition as to withstand the action of the elements, particularly that of salt water, without etching, discoloration, change in the color density of colored lenses, or any change in the light transmission of the finished glassware beyond the limits specified in paragraph 4(*e*) of these specifications.

(*a*)2. Clear, green and blue lenses (Grades A, C and D) shall be made from the best quality of lead glass.

(*a*)3. Red lenses (Grade B) shall be of the so-called selenium red glass and shall be made from the best quality of zinc-borosilicate glass.

(*a*)4. Fresnal lenses shall be designed to have a central bull's-eye and 4 zones above and 4 below this central zone. The mathematical design of the lens shall be such as to produce not more than an 8° dispersion above or below the horizontal axis of the central bull's-eye when used with a standard 40 watt incandescent lamp located at the focus of the system. Actual figuring of this design shall be at the option of the manufacturer as to the surface curvatures, spacing of zones, width of zones, etc., and the statement of the mathematical derivation of this design will not be required to be furnished by the manufacturer.

(*a*)5. The design of the system as a Fresnal lens shall be such that the rays emitted by a light source of a $^1/_4$″ sphere, placed at the focus of the system and passing through the system, shall emerge parallel. When the lens, with the above type of light source, is viewed at a distance of 20 feet along the horizontal axis of the bull's eye the zones shall all appear equally illuminated, the light showing through the zones as an uninterrupted vertical strip about $^1/_4$″ wide, for the entire height of the lens.

(*a*)6. Lenses shall be so designed and constructed as to be capable of withstanding an external hydrostatic pressure of 100 pounds per square inch indefinitely, when mounted in a support so designed as to produce a minimum strain on the lens.

(*a*)7. The several grades of glassware (A, B, C and D) furnished under Class 1 shall be subject to the following individual grade requirements:

(I) *Grade A—Clear.* The glass shall be free from perceptible tint when viewed through the lens. The entire visible spectrum of the light source shall be transmitted with color selection at any wave-length being kept below $^1/_2$ of 1%. The light transmission shall be in accordance with Table I.

(II) *Grade B—Red.* The glass shall be of such color quality that all light of shorter wave-length than 0.630 micron shall be absorbed, transmitting only red and orange light. All rays emitted by the sodium flame shall be completely absorbed. The color density and light transmission shall be in conformity with Tables I and II of these specifications.

(III) *Grade C—Green.* The glass shall be of such color quality as to absorb all of the light of longer wave-length than 0.570 micron, transmitting only violet, blue and green light. The color density and light transmission shall be in conformity with Tables I and II of these specifications.

(IV) *Grade D—Blue.* The glass shall be of such color quality that all light of longer wave-length than 0.489 micron shall be absorbed, transmitting only violet and blue light. The glass shall not, under any condition of light source, transmit any red or yellow light. The color density and light transmission shall be in conformity with Table I of these specifications. The glass of the lens shall, when used with a 25-watt standard tungsten lamp operating at rated voltage, show a direct visibility not to exceed 1000 yards; and, the indirect reflected rays shall not be visible over 200 yards on a dark night with a clear atmosphere.

Class 2. Heat Resisting Globes

5(*b*)1. *Grade E.* The glass shall be of a special heat resisting type and shall have an extremely low temperature coefficient of expansion. The unmounted heat resisting globe shall be capable of withstanding the internal stresses produced when the globe is heated uniformly to a temperature of 150°C and then suddenly and completely, or partly, immersed in water at 10°C, or, it shall be capable of withstanding a sudden change in temperature of 140°C. Under this treatment the glass shall not be injured in any way, either visibly or structurally. It shall be capable of withstanding this treatment repeated indefinitely.

(*b*)2. The glass shall be either a "Lead glass" or a "Borosilicate glass." It shall be of such composition as to withstand the action of the elements, particularly that of salt water, without etching, discoloration, or any change in the light transmission of the finished glassware beyond the limits specified hereunder.

(*b*)3. The glass shall be clear as to light transmission and it shall show

a light absorption not to exceed 4% for white light, nor a selective absorption exceeding ½ of 1% for any wave-length between 0.420 micron (violet) and 0.680 micron (red).

(*b*)4. The glass shall be suitable for use as an outer globe in a fixture in which a filter lens (Class 1—clear, red, green or blue—see paragraph 5(*a*)1 to 5(*a*)7, incl.) is used, without materially affecting the total light transmission of the assembly. When used with a filter lens, which lens in itself complies with these specifications, the combination shall show a light transmission within the limits of Tables I and II for the particular grade and color of lens with which the heat resisting globe is used.

(*b*)5. The glass shall be reasonably free from striae, bubbles, wrinkles or other defects which may be considered detrimental to its appearance, optical qualities or serviceability. The glass shall be of such mechanical strength as to render it capable of withstanding for an indefinite period, a continuous or fluctuating external hydrostatic pressure of 300 pounds per square inch, when permanently mounted in the fixture in which it is designed to be used.

Class 3. Globes

5(*c*)1. The glassware under this class may be of any stable commercial glass composition excepting a zinc glass. It shall be of such composition and quality as to withstand the atmospheric sea conditions which exist below deck without etching, discoloration or a change in color density or light transmission beyond the limits specified in Tables I and II.

(*c*)2. Globes or shades shall show no defined dead spots when illuminated from the inside and viewed from the outside. The glassware shall be of uniform thickness, within the tolerances specified.

(*c*)3. *Grade F—Translucent.* The translucent glass shall be of a totally diffusing milk glass, of uniform density, and shall be so made as to break up the light and eliminate any light source image. The glass shall transmit the entire spectrum, with absorptive selection in the red end of the spectrum desirable but not imperative. The light transmission shall be in accordance with Table I of these specifications.

(*c*)4. *Grade G—Red.* The glass shall be of such color quality that all light of shorter wave-length than 0.630 micron shall be absorbed, transmitting only red and orange light. All rays emitted by the sodium flame shall be completely absorbed. The color density and light transmission shall be in conformity with Tables I and II of these specifications.

(*c*)5. *Grade H—Green.* The glass shall be of such color quality as to absorb all of the light of longer wave-length than 0.570 micron, transmitting only violet, blue and green light. The color density and light transmission shall be in conformity with Tables I and II of these specifications.

(*c*)6. *Grade I—Blue.* The glass shall be of such color quality that all light of longer wave-length than 0.489 micron shall be absorbed, trans-

mitting only violet and blue light. The glass shall not, under any condition of light source, transmit any red or yellow light. The color density and light transmission shall be in conformity with Table I of these specifications. The glass of the globes shall, when used with a 25-watt standard Tungsten lamp operating at rated voltage, show a direct visibility not to exceed 1000 yards; and, the indirect reflected rays shall not be visible over 200 yards on a dark night with a clear atmosphere.

Method of Inspection, Tests, etc.

6. Inspection at the place of manufacture shall consist of the following:

(*a*) *Dimensional and Surface Inspection.* Each piece of glassware submitted for inspection under a contract or order shall be subjected to a careful inspection to ascertain that the dimensions are within the specified

TABLE III

No. of samples	No. of pieces of same type, class and grade, submitted in one lot or fraction thereof
1	25
2	100
3	200
4	500
5	1000
6	1500
7	2000
8	5000
10	10000

NOTE: The samples referred to in the above table refer only to glassware which is satisfactory to the Inspector as regards dimensions and workmanship. For samples which refer to rejected material under controversy see paragraph 8(*d*) of these specifications.

tolerances and that the workmanship is first class in every particular. The naval inspector concerned shall be the judge as to the size and number of small bubbles, striae, mold marks, wrinkles, chipped edges or other slight blemishes which are sufficient to detract appreciably from the serviceability of the lens or globe.

(*b*) *Specimens for Laboratory Tests.* Lenses or globes, to the quantity indicated in Table III hereunder, shall be selected by the Naval Inspector for forwarding to the Government Laboratory designated by the Bureau concerned. The samples shall be selected after the dimensional and surface inspection referred to in sub-paragraph 6(*a*) above has been made and they shall represent the poorest of the lot which, in the Inspector's judgment, are otherwise acceptable. No two samples shall come from the same pot of molten material.

(*c*) *Color Density and Light Transmission Tests.*

(I) *Lenses (Class 1).* The tests for light transmission of a lens shall be made on the basis of the average of transmission. Tests shall be

made by illuminating the entire lens and photometrically reading the transmission of light. Color density shall be rated likewise, the spectrum analysis being taken with the entire lens illuminated and the spectroscope placed at a distance which will bring the entire lens into the field of the spectroscope.

(II) *Globes (Classes 2 and 3).* The testing of glassware under Classes 2 and 3, for color density and light transmission, shall be made on a section of the globe, taking various photometric and spectroscopic measurements on sections 1″ in diameter by blocking off the remainder of the globe. The transmission and spectral values for all sections or zones shall fall within the limits of Tables I and II of these specifications. The appearance of dead streaks in any of the material, even though the tested zones fall within the specified limits of transmission, shall be cause for the rejection of the material.

(*d*) *Chemical Analysis and Weathering Tests.* Chemical analysis shall be made of the material of the samples, to ascertain that the composition is in conformity with these specifications. Weathering tests covering a one-year period of time shall also be made when, in the opinion of the Government Laboratory concerned, there is reason to question the suitability of a particular glass composition for the service intended. Acceptance of material submitted under contract or order will not, however, be contingent upon the result of such tests unless there be grave doubt upon this point, in which case the contractor will be required to make out a special guarantee to cover a period of one year.

(*e*) Any further tests which, in the judgment of the Bureau concerned, are necessary to ascertain that the material submitted is in full conformity with these specifications.

Packing and Marking of Shipments

7(*a*) Glassware shall be suitably packed for shipment in strong wooden cases or barrels. The method of packing shall be such as to prevent breakage, chipping or marring of the glassware during shipment. Each lens, globe or shade shall be individually wrapped in paper of the color corresponding to the color of the glass.

(*b*) All packing cases shall be plainly marked with the manufacturer's name, the contract, requisition or order number, the quantity, and the class and grade as defined in paragraph 2 of these specifications.

Notes to Supply Officers, Bidders, Manufacturers and Others

8(*a*) All requisitions, schedules or orders shall specify the Class and Grade as defined in paragraph 2 of these specifications, and the number of the Navy Drawing, or Drawings, which apply.

(*b*) Bids for furnishing glassware differing from the requirements of these specifications will be considered, provided the bidder clearly describes in his bid the specific points in which the glassware he proposes to furnish differs from the requirements of the specifications, and provided further that the differences are indicated as such. When exceptions are not clearly described and indicated as such it will be assumed that bidders are offering glassware in strict accordance with these specifications.

(*c*) Government purchases of glassware under these specifications shall cover not less than 25 pieces of each type on order. By "each type" is meant all lenses or globes made to the same drawing and coming within the same grade classification. Refer to paragraph 2 of these specifications.

(*d*) In the event of a controversy between the contractor and the naval inspector relative to the acceptability of lenses or globes which contain slight striae, bubbles, mold marks or wrinkles, the procedure which is to be followed by the contractor in making an appeal shall be as follows: the inspector shall select one or more samples for forwarding to a government laboratory to be designated by the Bureau concerned. The sample or samples so selected shall represent the poorest specimens of the lot of glassware under controversy. The selected samples shall be marked by the inspector in such a way as to positively preclude any chance of substitution and are then to be shipped by the contractor, at his own expense, to the government laboratory designated. The Laboratory will investigate the effect of such blemishes upon the serviceability of the material in question and render its report to the inspector, a copy of such report, with recommendations, to be forwarded to the Bureau concerned for its information. In the interim between the forwarding of such controversial samples to the Government Laboratory and the receipt by the inspector of a test report therefrom, the material involved at the contractor's works shall have the status of rejected material, and any delay in deliveries under the navy contract or order shall not be attributable to the government. An appeal from the Inspector's decision, the proper procedure for which is outlined above, is to be considered in the light of a privilege conferred by the Bureau concerned, which privilege may be withdrawn whenever, in its judgment, withdrawal is considered desirable.

(*e*) Copies of these specifications may be obtained upon application to the Bureau of Engineering, Navy Dept., Washington, D. C.

REFRACTORIES QUESTION BOX

E. E. Ayars, Editor

Contributed discussions covering questions of interest to the refractories manufacturer and consumer will appear each month in this department. A list of questions, some of which were considered at the last annual

meeting, is printed herewith. The membership is requested to submit additional questions and to contribute to the discussion of such questions as they have information on. It is planned to give one or more questions a thorough treatment each month. Anyone wishing to submit discussions will send them to the office of the General Secretary properly marked for this department. Author's name should be signed, but may be withheld if requested.

Question: What is the value of the poidometer to a manufacturer of refractories?

(1) The poidometer may be used to feed material at a uniform rate to a pan, pug mill, or other machine.

(2) The poidometer is a continuous machine, that is not intermittent in its operation, and measures materials accurately by weight, therefore two or more poidometers may be used to advantage to properly proportion materials to be mixed as they are fed to a pan or pug mill.

(3) The poidometer is adapted to feed ground fire clay at a uniform rate to a pug mill feeding an auger machine, from which auger machine a column of uniform stiffness is desired.

(4) The poidometer is also furnished, when desired, with a water attachment, which furnishes water at a uniform rate for mixing with the clay.

(5) This water attachment, when desired, can also be connected to the parts controlling the flow of clay so that any change in density in the clay due to its change in moisture content may be compensated for by an increase or a decrease in the water supply as needed.

(6) Manufacturers of fire brick ship ground fire clay and manufacturers of silica brick, silica cement, and the poidometer may be used to weigh these materials continuously as they pass from the grinding equipment to the railroad cars in which they are loaded. We contemplate at this time purchasing a poidometer for use in weighing ground fire clay.

S. M. KIER. Pres., Kier Fire Brick Co., Pittsburgh, Pa.

Discussion on Cupola Bricks:

1. Should a cupola block be hard burned?
2. Will a repressed cupola block give better service than a hand-made block?
3. Is it better to use a high-grade bond clay or a low-grade bond clay in cupola blocks?
4. If cupola blocks come from the kiln soft, does it affect their wearing qualities to reburn them in the kilns?
5. What fusion point is desirable in a cupola block?

One of the first requirements for cupola blocks is that they be hard burned.

As a rule, machine made and repressed brick are more uniform in size and shape than hand-made blocks. This, of course, is an advantage, and if there is no pronounced tendency to lamination the repressed brick will give the better service.

If a high-grade bond clay is used, very little or no flint clay will be required. A block made of high grade bond clay and grog without any flint clay will give better service than a block made of a low grade bond clay with a larger percentage of flint clay added.

The writer is not convinced that a reburned fire clay shape is as good as one which has been properly burned the first time. We can give no theoretical explanation for this, but it has been our experience that the reburned ware is liable to be inferior.

About cone 29 is a desirable fusion point for cupola blocks.

E. H. VAN SCHOICK, Manager,
Chicago Retort and Fire Brick Co.,
Ottawa, Illinois

The service conditions to which a cupola block is subjected dictate whether or not it should be hard burned. Large cupolas as a rule require a hard-burned block, particularly in the car wheel foundry. There heavy scrap is charged with a large amount of flux and an all-day melting period is customary. Small cupolas pouring small castings, especially those on stove work, use a medium burned block. These installations have a short pouring period, being operated at a high temperature and pouring the metal very hot to get proper results with thin section castings. A hard-burned block under such conditions spalls badly.

The repressed cupola block is usually more uniform in size than the hand-made block, and will lay up with a much thinner joint. This is desirable, as it reduces the amount of patching caused by erosion and failure of joints.

There are four actions in the cupola which tend to destroy the fire brick lining (from *British Clayworker*).

(*a*) *Corrosion* of lining by furnace gases, fluxes, slag, fuel and molten metal.

(*b*) *Partial fusion* of brick in and near the hearth due to high temperatures.

(*c*) *Spalling* due to sudden temperature changes.

(*d*) *Abrasion* due to rubbing action of the descending charge.

Corrosion by slag is the main cause of failure. A porous brick should not be used, although a viscous slag will not attack a porous brick to any extent. A very fluid slag will attack almost any brick, especially one that is porous. This would indicate a hard-burned block in all cases.

Fusion is very slight. Spalling may be kept at a minimum by skilful furnace operation, even when very hard-burned and dense blocks are used.

Abrasion is usually slight and when hard blocks are laid up into a smooth wall with thin joints, it is not considered an important question. Abrasion

of a rough or patched wall is more or less severe in the case of large cupolas charging heavy scrap.

A refractoriness of cone 31 or over is considered desirable, although a lining with a fusion as low as cone 28 or 29 is satisfactory when the resistance to corrosion, spalling, etc. is suitable.

NOTE: Further discussion of this subject is solicited. Next Month: Discussion of refractories service in the air furnace.

ACTIVITIES OF THE SOCIETY

PRESIDENT'S PAGE

By Robert D. Landrum

This is my first opportunity to address all members of the Society. To the 475 men and 72 ladies registered at the Convention in Atlantic City, I pledged to do all that may devolve upon me as President to further the interests of the Society during the 1924 fiscal year. I wish here to reaffirm this pledge and to make it known to all.

Election to presidency of so large and so potentially and dynamically a useful Society of ceramists is an honor but, of more concern to me, it is a call to service which carries responsibilities and privileges that have caused me to make a thoughtful survey of what we are and what we can become. In this survey is an estimate of what the President should be and should do, which estimate is almost appalling. I find comfort and reasons for expectation of a successful year in the fact that the Society is growing in potency through personal collaboration of an increasing number of earnest men and women. After all, the Society is not what the President, the Secretary or any of the other officers and trustees will it to be; it is just what the members make of it.

Well do I remember the organizing meeting of the Enamel Division. A few men, mostly college trained, met out of curiosity to learn to what extent representatives from competing concerns would disclose information. A real good fellowship and informing time was had. Experiences were exchanged. The meeting adjourned with nearly one hundred per cent conversion of those present to the value of meeting together for the purpose of discussing methods of production. As time passed the number attending and participating increased. The plant operators and college investigators learned a common language so that today the number of factory operators taking an active part has increased many fold.

Rather significant, I take it, that 63% of the 184 papers presented at the Convention just held were from plant operators. This shows an appreciation of the plant man for opportunity to exchange information and experiences.

But neither facts nor information are obtainable without paying a price either by bartering things of like kind or in the coin of the realm. The American Ceramic Society is the exchange market where he who wishes to succeed may, indeed it is almost a case where he must, seek opportunity to exchange the little that is new in his experience for the much which his fellow members give in exchange. This really is the mainspring, the motive, the all-inspiring reason for the existence of the Society.

To so serve as President of this wonderful enterprise of mutual service that the growing confidence and interest will be accelerated at a greater rate during 1924, is my ambition. But I, after all, am only one of the members with a specially assigned task for the while. The burden of responsibility still rests with the members themselves.

MEMBERSHIP WORKERS' RECORD

On February 15, 1924, the grand total of membership in the Society was 2334. The number of personal members was 2030 and of corporations 304.

Our aim is to have each of these 2030 members intense workers for the Society, coping actively with the ceramic problems and situations of the present day. The honor of holding a membership in the Society is betrayed unless that membership is used for vigorous coöperation.

	Individual		Individual	Corporation
R. R. Danielson	1	R. F. Segsworth	1	
I. A. Krusen	1	K. H. Endell	1	
R. F. Geller	1	L. M. Moss	1	
G. H. Brown	1	August Staudt	1	
Thos. A. Shegog	1	A. Malinovsky	1	
Bruce F. Wagner	1	Robt. H. Armstrong	1	
Fred A. Harvey	2	C. C. Treischel	1	
C. W. Parmelee	3	Eugene J. Hysell	1	
J. M. Gilfillan	1	G. W. Cruikshank		1
Donald W. Ross	1	R. D. Landrum		1
James W. Moncrief	1	Francis T. Owens		1
Donald Hagar	1	H. F. Staley		1
W. A. Potter	1	Office	15	4
R. F. Ferguson	1		—	—
		Total	40	8

NEW MEMBERS RECEIVED FROM JANUARY 15 TO FEBRUARY 15

PERSONAL

Armstrong, Chas. C., Mgr., The Armstrong Mfg. Co., Huntington, W. Va.

Bidleman, William J., Mine Supt. and Field Works, Wellsville Fire Brick Co., and Chicago Fire Brick Co., Wellsville, Mo.

Bowles, Fanny Belle, Bldg. 95, Walter Reed Hospital, Washington, D. C., Reconstruction Aide, U. S. Army.

Brown, Leroy Walton, 221 S. Cook Ave., Trenton, N. J., Supt., Lenox, Inc.

Budnikoff, Peter, Professor Engineer technolog of mineral technology, Ivanovo-Vosnesiensk near Moscow, Russia.

Carter, C. C., Supt., Buckeye Tile Co., Chillicothe, O.

Eccles, Alfred Livingston, 16 Atterbury Ave., Trenton, N. J., Sales Engineer, Fletcher Works, Philadelphia, Pa.

Foraker, Ralph L., 1918 S. 48 Court, Cicero, Ill., Ceramic and Efficiency Work, Coonley Mfg. Co.

Griffin, Paul Frederick, U. S. Refractories Corp., Mt. Union, Pa.

Griffiths, Norman, Chemist, Eureka Terra Cotta and Tile Co., Ballarat, Victoria, Australia.

Haldeman, Virgil Kenneth, 318–13th St., Beaver Falls, Pa., Ceramic Engineer, Beaver Falls Art Tile Co.

Harris, Robert W., Dillsboro, N. C., Secy., Harris Clay Co.

Heinle, Frederick John, 34 Highland Ave., Washington, Pa., Engineer, Hazel-Atlas Glass Co.

Horner, E. H., Box 314, Stockton, Calif., Supt., Stockton Fire Brick Co.

Hugill, William, Department of Applied Science, St. George's Square, Sheffield, England.

King, Walter F., Ceramic Engineer and Plant Supervisor, Mosaic Tile Co., Matawan, N. J.

Koehler, Walter A., 39 Maple Ave., Morgantown, W. Va., Instructor, Chemical Engineering, W. Va. University.

Koppers, Dr. Heinrich, Essen, Moltkestrasse 29, Germany.

Lahovsky, Josef, Chief Chemist of the Zápoceské Tovarny Kaolinové a samotivé, Horni Bitza, Czechoslovakia.

Lefranc, Jacques, 29C, Rue St. Martin, Paris III, Chief of Laboratory, Conservatoire Nationale des Arts et Metiers.

Longbotham, Harry, 1711 San Lorenzo Ave., Berkeley, Calif., Pacific Sanitary Mfg. Co.

Lu, Kai-Ching, Box 123, University Station, Urbana, Ill., Student Member.

Lyttle, Frobisher T., Scarsdale, N. Y., Art Potter, Scarsdale Kilns.

McLaughlin, N. H., Alsey, Ill., Secy., Alsey Brick & Tile Co.

Mathiasen, Alfred, Secretary, Matawan Tile Co., Matawan, N. J.

Millar, Charles A., c/o Ontario Sewer Pipe and Clay Products Co., Toronto, Ont.

Morris, Thomas H., 1104–8th St., Huntington, W. Va., Factory Mgr., The Charles Baldo Glass Co.

Navratiel, Hans, Beuthen/O.-S. Parallelstr. 6, Germany, Ceramic Engineer.

Porter, J. Barton, 1527 Spruce St., Philadelphia, Pa., Engineer, General Electric Co.

Putnam, LeRoy Edward, 1032 So. Grove St., Irvington, N. J., Sales Engineer, Celite Products Co.

Robertson, H. M., 600 Century Bldg., Cleveland, Ohio, Engineer, Robertson-Pease Co.

Seeley, Wm. E., 728 Crocker St., Los Angeles, Calif., Supt., Columbia Glass Co.

Spangler, C. P., 1514 Denniston Ave., Pittsburgh, Pa., Industrial Engineer, James Laughlin Steel Corp.

Tailby, Roland V., 224 Graham St., Highland Park, N. J., Ceramist, Matawan Tile Co.

Thompson, Franklin S., Sayerville, N. J., Ceramist, Sayer and Fisher Co.

Weiser, Franklin S., 45 Prospect St., Waterbury, Conn., Research Engineer, Scovill Mfg. Co.

Whitford, Alfred W., Watsontown, Pa., Ceramic Engineer, Fiske & Co., Inc.

Williams, J. C., 1300 Pennsylvania Ave., N. W., Washington, D. C., Manager, Development Service, Southern Railway Co.

Windolph, Frank S., 1509 N. Frazier St., Philadelphia, Pa., Secy., Chambers Bros. Co., Manufacturers of Brick-making Machinery.

Woodside, Frank C., 100 Northumberland Road, Pittsfield, Mass., Supt., Pittsfield Works, Porcelain Plant, General Electric Co.

CORPORATIONS

Bradford Brick & Tile Co., Face Brick, Hollow Tile, Bradford, Pa., W. L. Hanley, Jr.

J. W. Cruikshank Engineering Co., Glass Factory Engineers, 230 Fifth Ave., Pittsburgh, Pa.

The Detroit Vapor Stove Co., Mfrs. of Stoves, Detroit, Mich., Alvin G. Sherman, Genl. Mgr.

Geist Mfg. Co., Mfgs. and Sales, Fuel Oil Burners, 2001 Atlantic Ave., Atlantic City, N. J.

Hazleton Brick Co., Manufacturing Bricks, 211 Markle Bank Bldg., Hazleton, Pa., Mr. Friedlander, Pres.

Humphreys Mfg. Co., Manufacturers, Sanitary Enameled Iron Ware, Mansfield, Ohio., Frank B. Mahoney.

McLanahan-Watkins Co., Mining and Milling Cyanite, Charlotte Court House, Va.

Milton Pressed Brick Co., Face Brick Mfrs., Milton, Ont., F. R. McCannell, Vice-Pres.

PERSONAL NOTES OF MEMBERS

John L. Carruthers is at present in Los Angeles, Calif., where he is installing a kiln at the Los Angeles Pressed Brick Co. Mr. Carruthers' address is 419 Majestic Bldg., Columbus, Ohio.

Albert S. Adcock is living at 1999 Iuka Ave., Columbus, Ohio.

Harry Barkby, formerly of Wheeling, W. Va., is now situated at 466 Nishannock Ave., New Castle, Pa.

E. N. Bunting, who for a number of years has been instructor in ceramics at the University of Illinois, has taken a position with the Western Electric Co., 463 West St., New York City.

H. T. Bush, formerly of Toronto, is living at Inglebush, Port Hope, Ontario, Canada.

S. F. Cox writes that his address has been changed from 1011 Coal St., Wilkinsburg, Pa. to Box 320, Brackenridge, Pa.

Thomas Stanley Curtis, President of the Vitrefrax Company, lives at 583 So. Templeton St., Huntington Park, Calif.

M. R. Cuthbertson gives as his new address Box 131, Ancon, Canal Zone, Panama. Mr. Cuthbertson formerly was located at Oroya, Peru, S. A.

J. H. Eccles requests that his correspondence be addressed 32 Broughton Ave., Montreal West, Quebec.

The name of **The Ohio Pottery Company** recently has been changed to the **Fraunfelter China Company.**

Park Hitchens, whose name was listed among the "unknowns" in February, is employed by the General Refractories Company at Philadelphia, Pa.

William Gardner, formerly of Ontario, Canada, is now situated with the Cleveland Feldspar Co., 10220 Michigan Ave., Cleveland, Ohio.

James R. Goodwin, formerly of East Liverpool, Ohio, is now situated with the Mt. Clemens Pottery Co. and is living at Ashcraft Apts., No. 4, Little Road, R. F. D. No. 1, Mt. Clemens, Mich.

G. M. Grady gives 24 W. Frambes St., Columbus, Ohio as his correct address.

Carl B. Harrop has moved his office from S. Third St. to 419 Majestic Bldg., Columbus, Ohio. Associated with him are C. D. Bossert, Frank M. Hartford, W. E. Cramer and J. L. Carruthers.

Dr. Havas has moved from Heidelberg to Magyarovar, Hungaria.

Wynne L. Jackson has moved from 111 S. Kilpatrick Ave., Chicago, Illinois, to Central Hotel, Richmond, Calif.

F. M. Koenig is now located at 1005 Lincoln Place, Brooklyn, N. Y.

I. A. Krusen has left Danville, Illinois, where he has been employed with the General Refractories Co. and has gone to Rockmart, Ga. to assist in the reorganization of a fire brick company. Mr. Krusen will act as vice president and general manager of this company.

Thomas N. Kurtz has moved from Hollidaysburg, Pa. to the University Club, Pittsburgh, Pa.

Crawford Madeira has moved from 900 North American Bldg. to the Atlantic Bldg., Philadelphia, Pa.

D. Keith McAfee, formerly of Newcastle, Pa. has moved to 814 N. Seventh St., Cambridge, Ohio..

E. G. Menart has notified the Secretary's office that he has moved from Newark, Ohio, to 506 Fulton Road, N. W., Canton, Ohio.

R. S. Olsen, formerly 501 E. Daniel St., Champaign, Ill., has moved to 5073 N. Lincoln St., Chicago, Ill.

C. R. Peregrine is now general manager of the Marion, Indiana, office of the Macbeth-Evans Glass Company.

Carl Perg has informed the Secretary's office that his correct address is P. O. Box 727, Des Plaines, Illinois.

Richard E. Reif is living at 1004 W. Nevada Ave., Urbana, Ill.

W. D. Richardson has moved from Michigan Ave., to 1473 Belmont Ave., Columbus, Ohio. His business address is 312 Schultz Bldg.

V. J. Roehm has resigned his position as research ceramist for the United States Potters Association, and is holding a similar position with Homer-Laughlin China Co., Newell, W. Va.

Samuel Rusoff, formerly of Anderson, Ind., has moved to 833 Market St., Zanesville, Ohio.

Vincent P. Schildmeyer is living at 96 Albert St., St. Bernard, Ohio. Mr. Schildmeyer formerly lived in Cincinnati.

Edward Schramm requests that his mail be sent to the Onondaga Pottery Co., Syracuse, N. Y.

Carl Seiler, of the Roessler and Hasslacher Chemical Company, has moved from 1127 N. Calvert St. to Falls Station, P. O. Box No. 5, Baltimore, Md.

G. T. Stowe is located at 812 Finance Bldg., Cleveland, Ohio.

W. F. Wenning is now living in his new home, 3354 Francisco St., Pittsburgh, Pa.

E. J. Winkleman, a February "unknown," is located at Winkleman Engineering Co., 460 Union Trust Bldg., Pittsburgh, Penna.

Glenn D. Williams, of Worcester, Mass., is living at the Y. M. C. A., Box 607.

Eugenie A. Worman, of Seattle, Wash., has moved to 1630 Boylston St., Parker Apts.

J. W. Wright, formerly of Charleroi, Pa., writes that his address is now Irwin, Illinois, c/o R. W. Flemings.

OFFICERS FOR 1924

R. D. Landrum, President, Box 8, Station D, Cleveland, O.
R. M. Howe, Vice-President, Kier Fire Brick Co., Pittsburgh, Pa.
R. C. Purdy, Secretary, Lord Hall, O. S. U., Columbus, O.
H. B. Henderson, Treasurer, Standard Pyrometric Cones, 1538 N. High St. Columbus, Ohio.

Board of Trustees

A. F. Greaves-Walker, Stevens, Inc., Stevens Pottery, Ga.
F. H. Riddle, Champion Porcelain Co., Detroit, Mich.
Art Division: F. H. Rhead, American Encaustic Tiling Co., Zanesville, Ohio.
Enamel Division: R. R. Danielson, Bureau of Standards, Washington, D. C.
Glass Division: J. C. Hostetter, Corning Glass Works, Corning, N. Y.
Heavy Clay Products Division: C. Forrest Tefft, Fiske & Co., Inc., Watsontown, Pa.
Refractories Division: J. S. McDowell, Harbison-Walker Refractories Co.
Terra Cotta Division: R. L. Clare, Federal Terra Cotta Co., Woodbridge, N. J.
White Ware Division: C. C. Treischel, R. T. Vanderbilt Co., 50 E. 42nd St., New York City.

Divisions

Art: Miss Mary G. Sheerer, Chairman, Newcomb School of Pottery, New Orleans, La.; Miss Margaret K. Cable, Vice-Chairman, Assistant Professor, University of North Dakota, Grand Forks, N. D.; Herbert S. Kirk, Secretary, Universal Sanitary Mfg. Co., New Castle, Pa.

Enamel: R. R. Danielson, Chairman, Bureau of Standards, Washington, D. C.; H. G. Wolfram, Secretary, Bureau of Standards, Washington, D. C.

Glass: G. E. Barton, Chairman, 227 Pine St., Millville, N. J.; A. N. Finn, Secretary, Bureau of Standards, Washington, D. C.

Heavy Clay Products: F. T. Owens, Chairman, Fiske & Co., Inc., Watsontown, Pa.; John D. Martin, Vice-Chairman, Straitsville Impervious Brick Co., New Straitsville, Ohio; Amos P. Potts, Secretary, 118 E. Blaine St., Brazil, Ind.

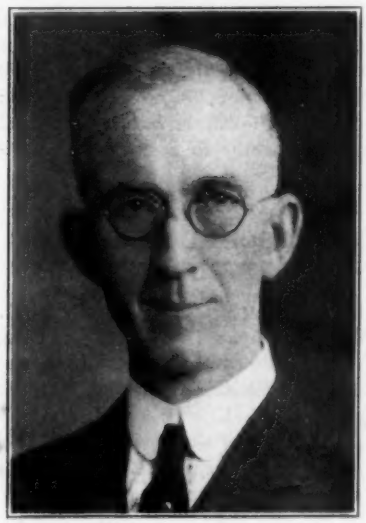
Refractories: Fred A. Harvey, Chairman, U. S. Refractories Corporation, Mt. Union, Pa.; C. E. Bales, Vice-Chairman, Louisville Fire Brick Works, Highland Park, Ky.; R. F. Ferguson, Secretary, Mellon Institute, Pittsburgh, Pa.

Terra Cotta: W. D. Gates, Chairman, American Terra Cotta and Ceramic Co., 1808 Prairie Ave., Chicago, Ill.; B. S. Radcliffe, Secretary, Northwestern Terra Cotta Co., 2525 Clybourne Ave., Chicago, Ill.

White Ware: F. H. Riddle, Chairman, Champion Porcelain Co., Detroit, Mich.; C. C. Treischel, Secretary, R. T. Vanderbilt Co., 50 E. 42nd St., New York, N. Y.

H. B. HENDERSON, TREASURER OF THE AMERICAN CERAMIC SOCIETY

H. B. Henderson, recently elected treasurer of the AMERICAN CERAMIC SOCIETY was graduated from Ohio State University with the degree of Bachelor of Science in 1904. For the past eighteen years he has been employed with General Edward Orton



H. B. HENDERSON

H. G. WOLFRAM

in the manufacture of pyrometric cones, now serving as superintendent of the Standard Pyrometric Cone Company of Columbus, Ohio. Mr. Henderson has been a member of the SOCIETY since 1904 and an active member since 1917. Mr. Henderson has contributed to the *Transactions of the American Ceramic Society* and *Journal.*

H. G. WOLFRAM, NEW SECRETARY OF ENAMEL DIVISION

H. G. Wolfram, born Des Plaines, Illinois, 1896. 1915–1918, employed in enamel shop of Royal Enameling & Mfg. Co. (later Benjamin Electric & Mfg. Co.). 1918–1919, Private, 108 Eng. 33rd Div., A. E. F. Entered the University of Illinois, 1919,

and graduated with B. S. Degree in Ceramic Engineering, 1923. Since that time has been connected with the Enameled Metal Section, U. S. Bureau of Standards, Washington, D C. Recently elected Secretary of the Enamel Division of the SOCIETY. Has contributed one article to the *Journal*.

TO EDIT REFRACTORIES QUESTION BOX

ERLING E. AYARS

E. E. Ayars was born in Little Genesee, N. Y., 1894. Graduated from Alfred University, 1917, B.S. degree in Ceramic Engineering. Employed by American Refractories Co., Baltimore, 1917; U. S. Fuel Administration, Washington, D. C., 1918; Asst. Supt. American Refractories Co., Baltimore, 1919 and 1920; Supt., Danville, Ill., 1921, Devils Lake, Wis., 1922, Joliet, Ill., 1922–23. Mr. Ayars was engaged February 1st by the El Paso Brick Co., El Paso, Texas, to develop a fire brick from local refractory clays. Associate member AMERICAN CERAMIC SOCIETY, 1916. Active member, 1921. Chairman, Program Committee, Refractories, 1922, and Chairman Refractories Division, 1923. Editor of Refractories Question Box in the *Bulletin*, 1924. Contributed frequently to SOCIETY publications.

C. C. TREISCHEL GOES TO R. T. VANDERBILT COMPANY

The Pottery Department of the R. T. Vanderbilt Company, which is in charge of Ira E. Sproat, announce that they have secured the services of Chester C. Treischel of the General Electric Company Potteries at Schenectady, N. Y. and Pittsfield, Mass., effective March 1.

Mr. Treischel is a graduate in Ceramic Engineering of the University of Illinois, and for the past six years has been associated with the General Electric Company. He is a well-known Ceramic Engineer, having been Secretary of the White Wares Division of the AMERICAN CERAMIC SOCIETY for the past three years and at the annual meeting of the SOCIETY in Atlantic City he was elected a Trustee of the SOCIETY.

NOTES AND NEWS

CERAMIC EXPERIMENT STATION NEWS

P. D. Helser Accepts Appointment Perry D. Helser has resigned his position as ceramic engineer with the A. C. Spark Plug Company of Flint, Mich., in which capacity he served for five years, to accept appointment to a similar position with the Department of the Interior, Bureau of Mines, Ceramic Experiment Station at Columbus, Ohio effective February 1, 1924.

Mr. Helser enters the service of the Bureau especially well equipped to supervise several of the problems now under investigation both at the Columbus station and in the field.

Utilization of Mineral Cyanite

There has recently been a coöperative agreement entered into with the Department of the Interior relative to the utilization of the mineral cyanite in the manufacture of refractory materials as well as in porcelain. This investigation will be conducted at the Bureau of Mines, Ceramic Experiment Station, Columbus, Ohio.

The mineral cyanite like andalusite, which is being successfully used in the ceramic industry, has the same composition as sillimanite but differs from it in mineral formation. The merits of the mineral sillimanite as a desirable ingredient in ceramic products are fairly well known. The resulting mineral formations if produced under the proper firing conditions, impart to the ware the properties of unusual resistance to sudden temperature changes, exceptionally high mechanical strength and greatly increased electrical insulation, at both normal and elevated temperatures.

When used in special refractories composed almost entirely of sillimanite, as far as some recent investigations have progressed, the results would indicate that such refractories will be well suited for use in the metallurgical field because of the high resistance to sudden temperature changes, the ability to stand up under load at elevated temperatures and because of the neutral nature of the material.

Ohio and Kentucky Fire Clays to be Investigated

The U. S. Bureau of Mines upon request of the Refractories Manufacturers Association has agreed to make a survey of the burning conditions at plants manufacturing fire clay refractories in the Ohio and Kentucky field. The survey will be carried out under the direction of the superintendent of the Ceramic Experiment Station in coöperation with the Fuel Section of the Bureau and will include approximately twenty plants.

CERAMICS SHORT COURSE, UNIVERSITY OF ILLINOIS

The ceramic department of the University of Illinois, under the direction of C. W. Parmelee, professor of ceramic engineering and head of the department, conducted a successful short course in clay working and enameling, January 14–25, 1924. Prof. Parmelee was assisted by the following lecturers and instructors from the University of Illinois:

M. S. KETCHUM, Dean of the College of Engineering and Director of the Engineering Experiment Station.
S. W. PARR, Professor of Applied Chemistry.
MORGAN BROOKS, Professor of Electrical Engineering.
E. B. PAINE, Professor of Electrical Engineering.
O. A. HARKER, Professor of Law.
E. W. LEHMANN, Professor of Farm Mechanics.
B. W. BENEDICT, Manager of the Machine Shop Laboratories.
A. P. KRATZ, Research Professor of Mechanical Engineering.
A. M. BUSWELL, Chief, Illinois State Water Survey.
R. K. HURSH, Associate Professor of Ceramic Engineering.
A. E. DRUCKER, Assistant Professor of Mining Engineering.
F. M. PORTER, Assistant Professor of General Engineering Drawing.

F. E. RICHART, Research Assistant Professor of Theoretical and Applied Mechanics.
E. N. BUNTING, Research Associate in Ceramic Engineering.
C. H. CASBERG, Superintendent of the Machine Shop Laboratory.
T. N. MCVAY, Instructor in Ceramic Engineering.
R. T. WATKINS, Assistant in Ceramic Engineering.
E. G. BOURNE, Laboratory Demonstrator in Ceramic Engineering.

Visiting Lecturers were:

R. R. DANIELSON, U. S. Bureau of Standards, Washington, D. C.
R. M. Howe, The Kier Fire Brick Company, Pittsburgh, Pa.
A. S. WATTS, Head of the Department of Ceramic Engineering, Ohio State University.

Lectures were given on the following subjects:

1. Origin and Properties of Clays. (Eight lectures.) Prof. Parmelee.
2. Elementary Physics and Chemistry. (Twelve lectures.) Dr. Bunting.
3. Explosives and Blasting. (One lecture, illustrated.) Prof. Drucker.
4. Business Law. (Two lectures.) Prof. Harker.
5. The Composition and Properties of Coal. (One lecture.) Prof. Park.
6. Steam Engines and Boilers. (Two lectures, illustrated.) Prof. Kratz.
7. Boiler Water. (One lecture, illustrated.) Prof. Buswell.
8. Dynamos and Motors. (Two lectures.) Prof. Paine.
9. Drying. (Four lectures.) Prof. Hursh.
10. Burning. (Four lectures.) Prof. Hursh.
11. The Use of Clay Products on the Farm. (One lecture.) Prof. Lehmann.
12. Maximum Production from Equipment. (One lecture.) Mr. Benedict.
13. Pyrometers. (Two lectures.) Mr. McVay.
14. Glazes. (Six lectures.) Prof. Parmelee.
15. Prospecting and Sampling. (One lecture.) Mr. McVay.
16. Periodic Kilns. (Two lectures.) Prof. Hursh.
17. Continuous Kilns. (One lecture.) Prof. Hursh.
18. Car Tunnel Kilns. (One lecture.) Prof. Hursh.
19. Care and Maintenance of Machinery. (One lecture, illustrated.) Mr. Casberg.
20. Physical Tests of Clay Products. (One lecture.) Prof. Richart.
21. Winning of Clays. (Two lectures.) Mr. McVay.
22. The Reading of Drawings. (Two lectures.) Prof. Porter.
23. Clay Haulage. (Two lectures.) Mr. McVay.
24. Lighting of Factories and Showrooms. (Two lectures.) Prof. Brooks.
25. Burning Brick for Color. (Two lectures.) Mr. McVay.
26. Fuel Economy. (One lecture.) Prof. Hursh.
27. Plant Problems. Prof. Hursh.
28. Dies and Auger Machines. (Two lectures.) Prof. Hursh.
29. Refractory Materials. (Four lectures.) Mr. Howe.
30. Vitreous Enamels. (Six lectures.) Mr. Danielson.
31. Bodies. (Four lectures.) Prof. Watts.
32. Grinding. (One lecture.) Mr. McVay.
33. Screenings. (One lecture.) Mr. McVay.

A very pleasant feature of the Short Course was a dinner tendered by those attending to the staff of lecturers. This dinner was presided over by Walter P. Wood of the Best Brick Company, Evansville, Indiana, who also arranged a very clever parody in which various members of the Short Course showed the staff of lecturers some of their

foibles. This impromptu entertainment was very amusing and demonstrated that there was a good deal of talent among the group which had not been previously suspected.

Those who registered for this course were:

ALABAMA:

Geo. R. Houston, Birmingham Clay Products Co., Birmingham, Ala.
Ladd, T. E., Southern Refractories Co., Fort Payne, Ala.
Staley, E. L., Sheffield Brick Co., Sheffield Ala.

COLORADO:

LeRoy, Marz, Denver Terra Cotta Co. (Western Plant of the Northwestern Terra Cotta Co.), Denver, Colo.

CALIFORNIA:

Lacy, Roy, Pacific Clay Products Co., Los Angeles, Calif.
Sauters, T. E., Pacific Clay Products Co., Los Angeles, Calif.

ILLINOIS:

Sir, Walter, Chicago Pottery Co., 1924 Clybourne Ave., Chicago.
Cerny, J. J., Northwestern Terra Cotta Co., Cicero, Illinois.
Cruikshank, P. H., Mueller Mfg. Co., Decatur.
Hinman, R. B., Editorial Dept., Ceramic Industry, 407 So. Dearborn, Chicago.
Manley, Rowland Peoples Gas Light and Coke Co., Room 325, 122 So. Michigan Ave., Chicago.
Pegram, Jas., Jr., Carrollton, Illinois.
Starck, John A., Fulton Clay Pipe Factory, Fulton, Ill.
Wilcox, Geo. L., John Wilcox and Sons, McLean, Illinois.
Woare, Edw. M., Decatur Brick Mfg. Co., Decatur.
Wright, Everett, L., Decatur Brick Mfg. Co., Decatur.
Kamm, R. J., Highland Brick and Tile Co., Highland, Ill.
Roefer, C. M., Elgin, Illinois.
Babtist, Hugo, Springfield Paving Brick Co., Springfield, Ill.
Moose, J. E., Chemistry Department, University of Illinois.
Gaskin, T. D., Midland Terra Cotta Co., Chicago.
Carter, R. F., Peoria Brick and Tile Co., Peoria, Illinois.
Gauthier, Chas. B., 107 Blooming Bank Rd., Riverside, Illinois. (Research Engr., Western Electric Co.).

INDIANA:

Casey, J. B., Colfax Drain Tile Co., Crawfordsville, Ind.
Landers, Wm. F., Jr., United States Encaustic Tile Works, Indianapolis.
Wood, Walter, P., Best Brick Co., Evansville, Ind.

MISSOURI:

Guenther, William, Bridge and Beach Mfg. Co., St. Louis, Mo.
Bradley, R. S., A. P. Green Fire Brick Co., Mexico, Mo.
McCann, F. A., A. P. Green Fire Brick Co., Mexico, Mo.

OHIO:

Cornelius, V. R., Metropolitan Paving Brick Co., Canton, O.
McCallin, P. J., Metropolitan Paving Brick Co., Canton, O.
Yohe, L. C., Metropolitan Paving Brick Co., Canton, O.
Emig, W. R., Toledo Scale Co., Toledo, Ohio.

Lynn, Horace K., Summitville Face Brick Co., Summitville, O.
McNeil, Daniel W., The John Douglas Co., Cincinnati.
Schildmeyer, Vincent P., The Cincinnati Porcelain Co., Cincinnati, O.
Vormelker, Howard I., National Lamp Works of General Electric Co., East Cleveland, Ohio.
Ketchem, Edw. R., Estate Stove Co., Hamilton, O.
Dimmick, R. B., United Alloy Steel Corporation, Canton, O.

PENNSYLVANIA:

Clowes, Edwin A., McCullough-Dalzell Crucible Co., Pittsburgh.
Drummond, C. R., Fiske and Co., No. 5 Plant, Watsontown, Pa.
Seanor, J. G., Darlington Clay Products Co., Darlington, Pa.

TENNESSEE:

Harker, O. A., Jr., Dixie Brick and Tile Co., Puryear, Tenn.
Jackson, Walter H., Dixie Brick and Tile Co., Puryear, Tenn.
Murphy, Wayne F., Tennessee Enamel Mfg. Co., West Nashville, Tenn.

TEXAS:

Elders, Jno. A., Acme Brick Co., Millsap, Texas.
Kelly, J. W., Acme Brick Co., Denton, Texas.

KENTUCKY:

McDonald, P. C., Coral Ridge Clay Products Co., Louisville, Ky.

WISCONSIN:

Held, Henry J., Rundle Mfg. Co., Milwaukee, Wis.

IOWA CLAY PRODUCTS MANUFACTURERS

Convention and Short Course at Iowa State College

The members of the Iowa Clay Manufacturers Association met at Iowa State College for their Annual Convention and Short Course, February 14 and 15, 1924. The officers of the Association are:

President, Carl A. Reaver, Eldora Pipe and Tile Co., Eldora, Iowa.
Vice-President, W. A. Queale, Redfield Brick and Tile Co., Redfield, Iowa.
Treasurer, H. R. Straight, Adel Clay Products Co., Adel, Iowa.
Secretary, M. T. Straight, Adel Clay Products Co., Adel, Iowa.

The following program was presented during the two days convention and course of instruction. At the banquet which was held for the guests, each one was given a small matt glazed bowl of good workmanship and commercially perfect in quality, made from Iowa raw materials. These were presented by the Department of Ceramic Engineering, Iowa State College.

Program

1. Depreciation as a Factor in Production Cost, Dean Anson Marston, Iowa State College, Ames, Iowa.
2. Load-O-Grams, Starr E. Cogswell, Western Weighing and Inspection Bureau, Des Moines, Iowa.
3. Drain Tile Specifications and Testing, W. J. Schlick, Drainage Engr., Iowa State College, Ames, Iowa.

The Future of the Railroad Tunnel Kiln, H. R. Straight, Gen. Mgr., Adel Clay Products Co., Adel, Iowa.

5. Labor Saving Machinery, C. A. Thorp, Mechanical and Ceramic Engr., Des Moines, Iowa.
6. National Advertising Reflected in Economic Conditions, J. C. De Lay, Creston, Iowa.
7. Washing Iowa Coals, Prof. D. A. Moulton, Iowa State College, Ames, Iowa.
8. Selling Clay Products to the Building Material Dealer, C. B. Platt, Editor Permanent Construction, Des Moines, Iowa.
9. Simplification and Research, J. S. Sleeper, Hollow Tile Assn., Chicago, Ill.
10. Plant Operation, O. J. Whittemore, Sheffield Brick and Tile Co., Sheffield, Iowa.
11. Uses of Clay Products in Building Structures, Prof. A. H. Kimball, Iowa State College, Ames, Iowa.
12. The Outlook Ahead, John P. Wallace, Wallace's Farmer, Des Moines, Iowa.
13. Accounting Cost Control of Clay Products Plants, F. A. Guignon, Brick and Clay Record, Chicago, Ill.
14. Letters that Pull, Prof. A. Starbuck, Iowa State College, Ames, Iowa

Those attending the meeting were:

Alt, Leslie R., Sioux City Brick & Tile Co., Sioux City, Iowa
Bacon, E. C., Hollow Bldg. Tile Assn., Omaha, Nebraska
Barret, Wayne E., Adel Clay Products Co., Adel, Iowa
Bradshaw, E. P., Bradshaws Co., Fort Dodge, Iowa
Bristol, C. J., Globe Machinery Co., Des Moines, Iowa
Bucht, C. J., Boone Brick & Tile Co., Boone, Iowa
Carhart, F. F., Jackson Tile & Brick Co., Des Moines, Iowa
Chamber, J. T., Fate-Root-Heath Co., Plymouth, Ohio
Cogswell, Starr E., Western Weigh. and Inspection Bureau, Des Moines, Iowa
Cox, Paul E., Iowa State College, Ames, Iowa
Furman, M. C., Des Moines Brick & Tile Co., Des Moines, Iowa
Furness, J. H., Sheffield Brick & Tile Co., Sheffield, Iowa
Galvin, G. H., Rockford Brick & Tile Co., Rockford, Iowa
Green, John R., Northern Iowa Brick & Tile Co., Mason City, Iowa
Guignon, F. A., Brick & Clay Record, Chicago, Illinois
Irwin, W. J., Vincent Clay Products Co., Fort Dodge, Iowa
Jackson, W. L., Buckey Clay Products Co., Belle Plaine, Iowa
Johnson, S. C., Kalo Brick & Tile Co., Otho, Iowa
Love, J. P., Boone Brick & Tile Co., Boone, Iowa
McHose, Ray M., Nevada Brick & Tile Works, Nevada, Iowa
Martin, S. A., Centerville Brick Co., Centerville, Ia.
Miller, R. L., Green Tile & Brick Co., Cedar Rapids, Iowa
Neiswanzer, C. O., Standard Clay Products Co., Oskaloosa, Iowa
Page, D. C., Walter Bledsoe Co., Chicago, Illinois
Parks, J. G., Morey Clay Products Co., Ottumwa, Iowa
Pearse, F. D., National Clay Works, Mason City, Iowa
Platt, C. B., Platt Company, Des Moines, Iowa
Queale, W. A., Redfield Brick & Tile Co., Redfield, Iowa
Rawson, Cummins, Iowa Pipe and Tile Co., Des Moines, Iowa
Reaver, C. A., Eldora Pipe and Tile Co., Eldora, Iowa
Selby, Ralph L., Reliance Brick Co., Des Moines, Iowa
Schurr, Wm., Kalo Brick & Tile Co., Fort Dodge, Iowa
Sleeper, J. S., Hollow Bldg. Tile Assn., Chicago, Ill.

Souder, W. J., Des Moines Clay Co., Des Moines, Iowa
Straight, H. R., Adel Clay Products Co., Adel, Iowa
Straight, M. L., Adel Clay Products Co., Adel, Iowa
Strouse, H. S., Pawling & Harnischfeger Co., Milwaukee, Wisconsin
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Taylor, Mark A., Vincent Clay Products Co., Fort Dodge, Iowa
Tearson, H. C., Maxwell, Iowa
Thorpe, Clyde A., Des Moines, Iowa
Tolbert, Geo. M., Iowa Pipe & Tile Co., Des Moines, Iowa
Tramp, H. L., Creston Brick & Tile Co., Creston, Iowa
Treble, Herbert, Natl. Clay Products Association, Chicago, Illinois
Tungate, Chas. M., Iowa Mach. and Supply Co., Des Moines, Iowa
Tulla, Ralph W., Reliance Brick Co., Des Moines, Iowa
Vincent, Harry, Vincent Clay Products Co., Fort Dodge, Iowa
Watkins, M. M., Brown Instrument Co., Chicago, Illinois
Wells, F. G., Maxwell, Iowa
Wheaton, J. J., Sheffield Brick & Tile Co., Sheffield, Iowa
Witel, John, Toledo Brick & Tile Co., Toledo, Iowa
Zook, Samuel I., Des Moines Clay Products Co., Des Moines, Iowa

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CALENDAR OF CONVENTIONS[1]

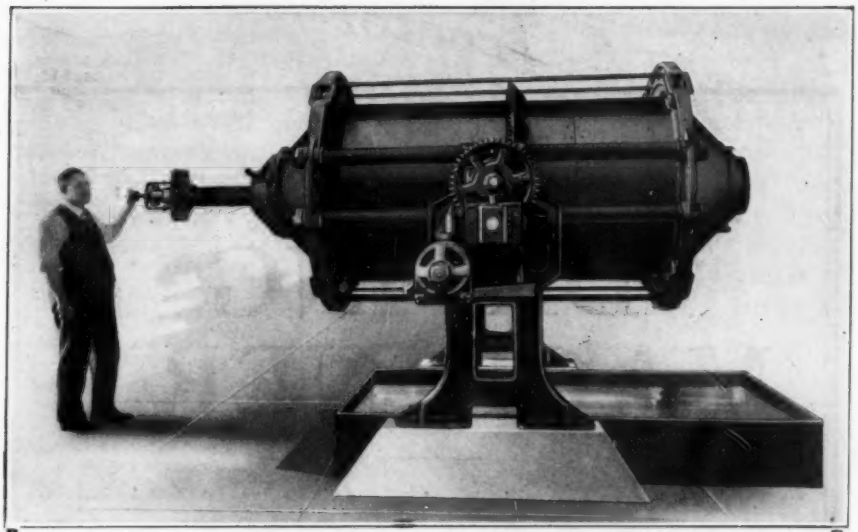
Organization	Date	Place
AMERICAN CERAMIC SOCIETY (Summer Meeting)	July 21–Aug. 16, 1924	Trip to Pacific Coast
Am. Foundrymen's Assn.	Oct., 1924	
Am. Gas Assn., Inc.	Oct., 1924	
Am. Iron and Steel Institute	May 23, 1924	New York
Am. Zinc Institute, Inc.	Apr. 28–29, 1924	St. Louis, Mo.
Assn. of Scientific Apparatus Makers of U. S. A.	Apr. 25–26, 1924	Washington, D. C. Bureau of Standards
Chamber of Commerce of the United States	May 6–8, 1924	Cleveland, Ohio
Chemical Equipment Assn.	Sept., 1924	
Eastern Clay Products Assn.	Apr., 1924	
Eastern Paving Brick Mfrs. Assn.	Dec. 9, 1924	New York (?)
Glass Container Assn. of America	Apr. 25, 1924	Atlantic City
Glazed and Fancy Paper Mfrs. Assn.	Week of Apr. 7, 1924	New York
Manufacturing Chemists Assn.	June, 1924	New York
Mirror Mfrs. Assn.	Mar., 1924	Pittsburgh
Natl. Assn. of Brass Mfrs.	Mar. 12–14, 1924	West Baden Springs, Ind.
Natl. Assn. of Mfrs. of Pressed and Blown Glassware	Mar., 1924	Pittsburgh
Natl. Assn. of Mfrs. of the U. S. A.	May 19–21, 1924	New York
Natl. Assn. of Stove Mfrs.	May 14–15, 1924	New York, Hotel Astor

[1] Further information may be secured through the Chamber of Commerce of U. S., Washington, D. C.

Natl. Bottle Mfrs. Assn.	Last Week in Apr., 1924	Atlantic City
Natl. Glass Distributors Assn.	Dec., 1924	Pittsburgh
Natl. Ornamental Glass Mfrs. Assn. of U. S. and Canada	June 24–26, 1924	New York
Natl. Paving Brick Mfrs. Assn.	Dec., 1924	
Penna. Gas. Assn.	April, 1924	Atlantic City
Refractories Mfrs. Assn.	Mar. 19, 1924	St. Louis, Mo. (?)
Society of Promotion Engineering Education	July, 1924	Boulder, Colo.
Stoker Mfrs. Assn.	May or June, 1924	
U. S. Potters Assn.	Dec., 1924	Washington, D. C. (?)
Western Glass and Pottery Assn.	June 15, 1924	Pittsburgh
Western Society of Engineers	June 4, 1924	Chicago

ERRATA

Bulletin of the American Ceramic Society, **3** [1], 39 (1924): Under the Biographical Sketch of Karl Turk, "Penn" System should read "Pemco" System.



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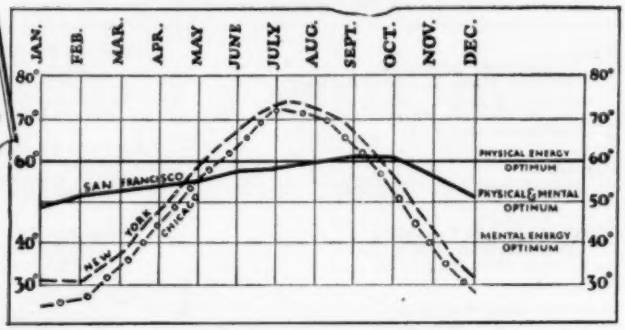

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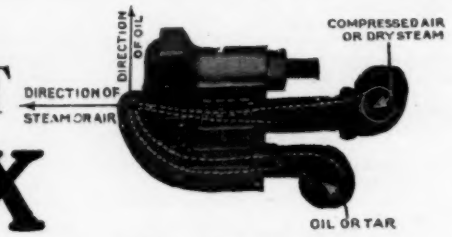

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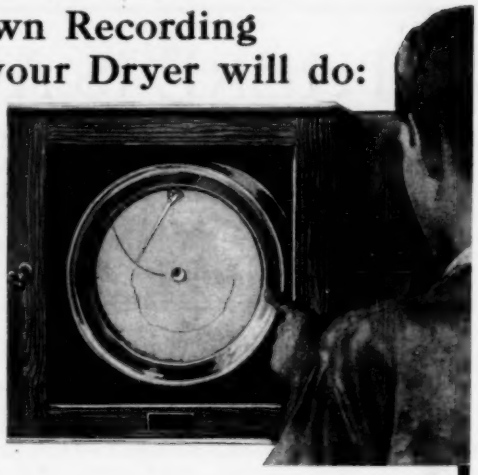

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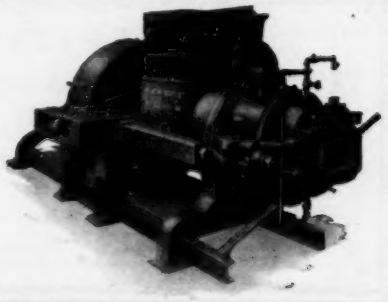

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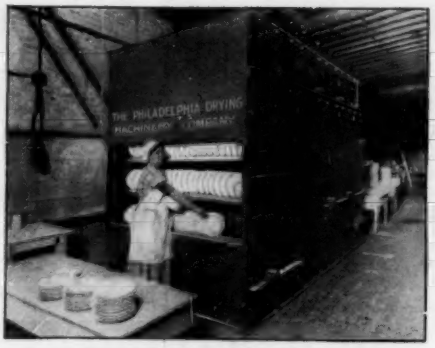

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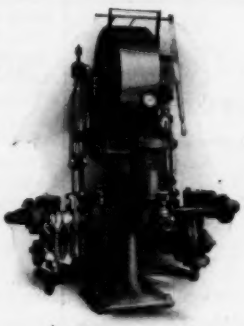

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